Power and The Engineer

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THERE is a widely spread and deeply grounded conviction that the loss due to clearance can be nullified by compression.

The unscientific engineer believes it because he sees that if the clearance is full of steam brought by compression to the initial pressure there will be no call for steam from the boiler to fill it; and that if the compressed steam gives back as much energy by expansion as it takes to compress it, this immunity will have been procured without cost.

The scientific engineer has taken the mathematical demonstrations of Zeuner of the same theorem too literally and has applied them too broadly.

If the expansion does not extend to the back pressure, the compressed steam does not have the opportunity to render back all the work that has been expended upon it by compression.

If the compression follows a different law from the expansion there will be no equivalence between the amounts of work absorbed and developed.

The thermodynamic deduction is very interesting and pretty, but it applies only to the abstract case, a perfect gas working in a non-conducting cylinder and with equal ratios of expansion and compression.

Victor Dwelshauvers-Dery, professor emeritus at the University of Liege, one of the first honorary members of the American Society of Mechanical Engineers, one of the first of the students of the steam engine from the scientific side, and the first to urge the value of a steam-engineering laboratory in connection with a technical school, started when, after years of persistent and unappreciated effort he had procured such a laboratory, to prove from the professional standpoint Zeuner's theorem by practical experiment.

Tests made with a precision which ranks with that of Regnault's classical investigation of the physical properties of steam demonstrated that *the more compression his engine had the less energy it developed per pound of steam consumed.*

The indicator diagrams made by the engine showed the terminal hook upon the compression line not uncommon upon diagrams from engines with considerable compression. Upon the publication of the results this hook was ascribed to leakage and attempts made to discredit the experiments.

Georges Duschene, one of Professor Dwelshauvers-Dery's assistants, suggested that if the hook was due to leakage it would appear if the engine were run with air. If, on the other hand, the fall in pressure were due to condensation, it should not appear when air was used.

The engine was run with compressed air *and the hook disappeared.*

It was plain that expensively produced work was being taken from the flywheel to heat up the cylinder walls.

Rear-Admiral Benjamin F. Isherwood, U. S. N., Ret., suggested that if the total work performed by the engine were kept constant there should be no difference in the steam consumption whatever the degree of compression, and experiment proved that he was right.

All this happened a number of years ago, but most American engineers are still ready to argue in favor of compression as a means of nullifying the effects of clearance.

The devotion of a large amount of space in this issue to a resume of Professor Dwelshauvers-Dery's work is warranted by the importance of the subject and the persistence of the lack of appreciation of the limited application in practice of the theoretical demonstration.

A Palatial Steam Power Plant

By A. R. Maujer

Light and power for Charles Schwab's mansion in New York City is furnished by a private plant. Besides being capable of competing with central station service, the plant is so carefully designed that continuity of operation is a practical certainty. In appearance the plant probably has no equal; in efficiency it will hold its own with any plant of its size.

In New York City, occupying the block bounded by Riverside Drive, Seventy-third street, West End avenue and Seventy-fourth street are the house and grounds of Charles M. Schwab, president of the Bethlehem Steel Company. The house is of such dimensions that it was found worth while to install in connection with the apparatus necessary for heating, equipment to generate the electric current needed for lighting, elevator service and numerous other purposes. Hence, we have the novelty of a full-fledged power plant containing three engine-driven generators of a total rated output of 250 kilowatts serving a private residence. The building contains 86 rooms the lighting of which requires 6000 incandescent lamps.

The power plant is located south of the building and is about 18 feet below the grade line. Fig. 2 shows the general arrangement of the engine and boiler rooms. The superintendent's office, Fig. 3, is on the ground floor and is reached by means of the stairway leading from the mezzanine floor in the engine room. Part of this stairway is shown in Fig. 5.

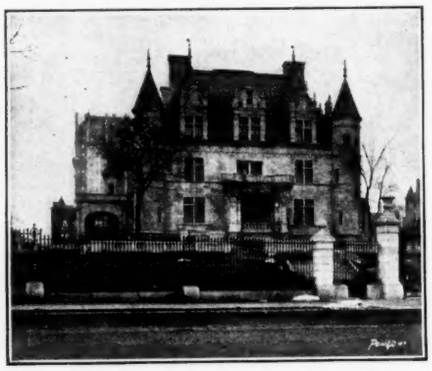


FIG. 1. THE NEW YORK HOME OF CHARLES M. SCHWAB

The three water-tube boilers, Fig. 4, were furnished by the Aultman & Taylor Machinery Company. The drums are 42 inches in diameter, 20 feet 2 inches long and made of 7/16-inch plate. Each boiler contains 72 tubes of No. 10 gage steel, 4 inches in diameter and 18 feet long. The total heating surface is 1510 square feet per boiler. Each boiler has two safety valves which are set for 120 pounds pressure per square inch. The hand-fired furnaces are fitted with shaking grates designed for burning No. 2 Buckwheat coal. The draft is controlled by a Kielly automatic damper regulator. The boilers are fitted with low-water alarms. A coal bunker and an ash hoist are located to the south of the boiler room. The capacity of the former is approximately 100 tons. As it is needed, the coal is weighed in the sheet-iron coal truck shown in Fig. 4 on a Fairbanks wagon scales, especially provided for the purpose, which is located in front of boiler No. 1.

Feed water is furnished by Worthington feed pumps 6 and 4 by 6 inches in size. There are five of these pumps in the pump room, which can be used for various other purposes as well as for boiler feed. Two are piped to a utility tank and are automatically controlled by a float system so as to keep the water level in the tank constant. All of the pumps are controlled by Kielly governors. A 3-inch Eynon-Körting compound injector is installed for emergency use. The pump room also contains the steam traps and the tank into which they discharge. At a lower level is located the blowoff tank which empties into a sump pit immediately underneath. A pump of the same size as those just mentioned is used to keep the sump clear. A small motor-driven centrifugal pump can be used for the same purpose when the boilers are out of service.

Steam is taken from the boilers through 8-inch lines which extend across the boiler room and drop down to a 16-inch header which is 7 feet above the floor line. From the header a main rises to a point near the ceiling, where it divides into two branches. One branch goes to a distributing header which is equipped with reducing valves. From this header steam is taken by various lines each of which has a reducing valve to reduce the pressure further as may be required. The other branch leads to the engine room through an automatic emergency valve and connects into a header from which the steam is passed through long copper bends to the separators at the engines.

In the engine room are two General Electric compound-wound direct-current generators designed for 800 amperes at 125 volts pressure and one unit of the same type which has a 400-ampere output. All are direct connected to Chandler & Taylor, automatic-cutoff, side-crank engines. The engines for the larger generators are 15x15 inches in size and that for the smaller unit is 11x12 inches. The

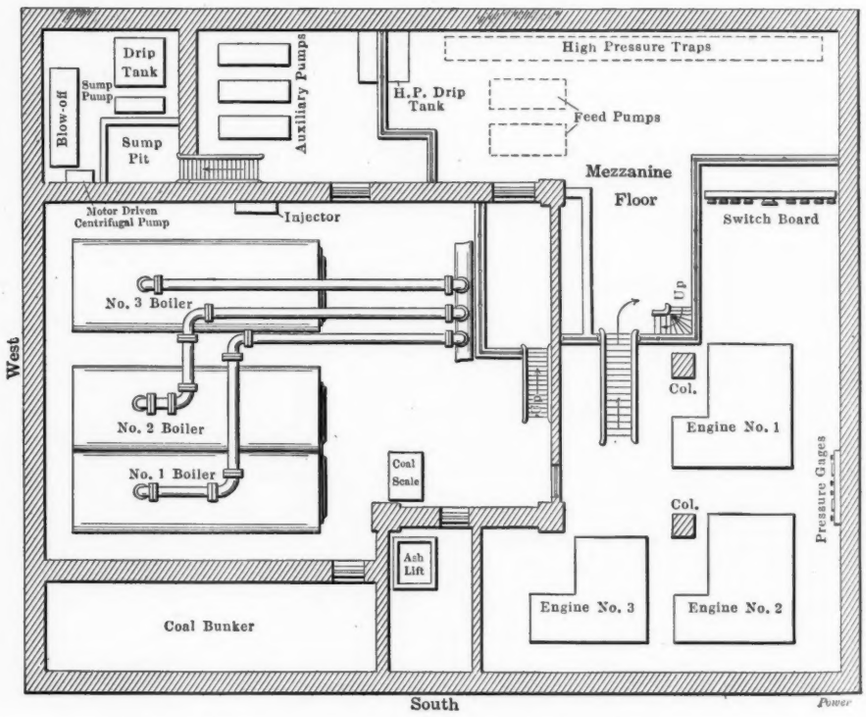


FIG. 2. GENERAL ARRANGEMENT OF POWER PLANT

speed of the large engines is 265 revolutions per minute; that of the smaller one is 280. All of the engines are fitted with Rites governors.

The engine oil is forced from a settling tank by air pressure to an overhead tank located in one corner of the engine room from which it is distributed by gravity to the various machines.

As shown in Fig. 2, a gage board is located on the east wall of the engine

FIG. 3. SUPERINTENDENT'S OFFICE ON GROUND FLOOR

room in a conspicuous position. On it are located gages for indicating the boiler pressure, the back pressure, and the pressures in the heating system and the laundry piping. The board is made of white Tennessee marble.

The switchboard has a separate panel for each unit. Each panel has a recording wattmeter for its machine. In addition, there is a recording voltmeter on the line. The instruments have a polished-bronze finish which forms a very pleasing combination with the white Tennessee marble of which the panels are made.

In a room under the main building are located the house and fire pumps. The house pump is 5¼ and 4¾ by 5 inches, and the fire pump is 7½ and 6 by 10 inches in size. These pumps are so connected that they may be used jointly in case of fire. One of the pumps serves the swimming pool which is in the basement and which has a capacity of about 17,000 gallons. The water used in the house, after passing through filters, flows to a tank which is located in the cellar and which has a capacity of approximately 1300 gallons. From this tank the water is pumped, as needed, to two storage tanks on the roof. These tanks have a combined capacity of about 5000 gallons. In the same room with the pumps just mentioned is the hot-water supply tank from which hot-water supply pipes are run to all parts of the house. The entire hot-water piping is made up of extra-heavy brass pipe tinned on the inside. The tank is fitted with a Davidson & Roesch temperature-control apparatus.

The vacuum-cleaning apparatus, which was furnished by the Kenney Vacuum Company, is driven by a 5-horsepower Crocker-Wheeler motor. Vacuum-cleaning service extends to every room in the house. This apparatus, as well as a

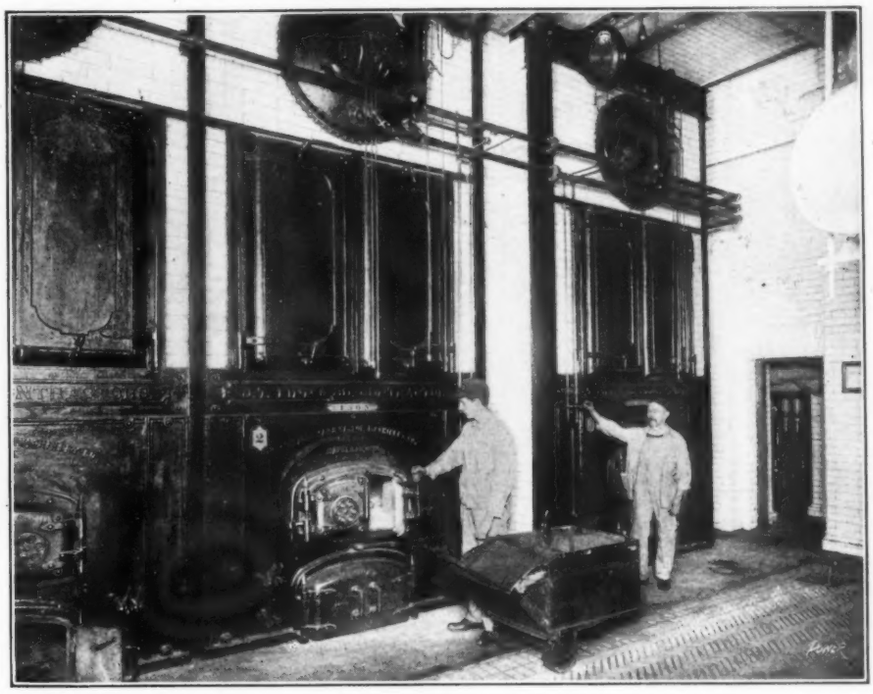


FIG. 4. THE BOILER ROOM

4 and 3½ by 6-inch air compressor which is used in connection with the thermostatic control system of the heating apparatus, is also located in the same room with the house and fire pumps.

Current from the main switchboard is conducted through conduits to the distributing board, Fig. 8, which is located in the main cellar. The end panels carry knife switches controlling motor or lighting circuits which are in regular daily use. The center panels carry fuses for electrically operated switches which are located behind the board. These switches

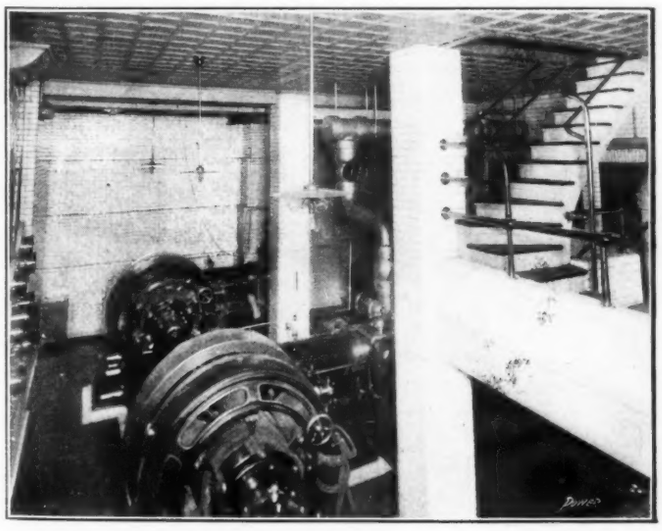


FIG. 5. VIEW OF ENGINE-ROOM MEZZANINE FLOOR

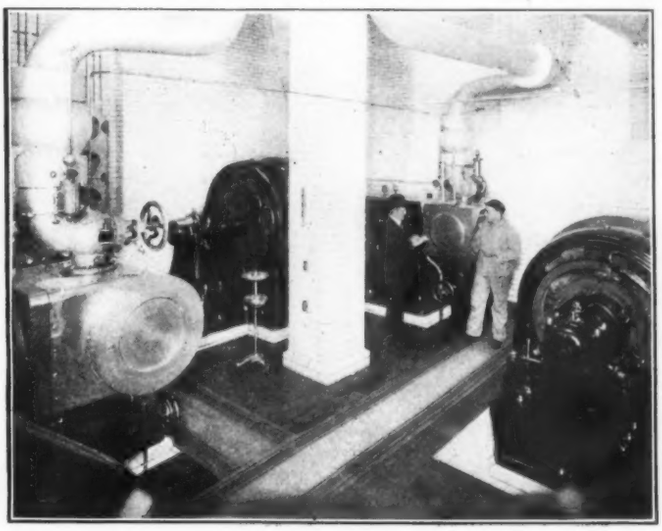


FIG. 6. VIEW OF ENGINE ROOM FROM BOILER ROOM

control large circuits which serve lamps concealed in the coves of all the main halls and rooms. The switches control circuits of from 100 to 400 lamps. Each switch is operated by means of a push button located in the various rooms.

kitchen elevator and the ash hoist are operated by a 9- and a 6-horsepower motor, respectively.

The house is heated by the indirect system. Two tunnels, each 4x6 feet in section, lead from a point on either side of the front terrace through the cellar to the heating chamber at the entrance of which the air passes through cloth filtering screens. The heating chamber contains 12 coils, each of which has a cross-section 16 feet wide by 8 feet high. Exhaust steam is used in the coils. Before going to the fan, the air passes through a humidifier where the desired amount of moisture is taken up. The runner of the motor-driven circulating fan is 6 feet in diameter. From the main duct in the cellar, individual branches conduct the air direct to the various rooms. Each of these branches is by-passed around a heater located in the duct itself. The heater and the dampers are operated from the rooms which the branches serve by means of thermostats which may be set to give any desired temperature. Ventilating ducts convey the foul air to exhaust fans on the roof.

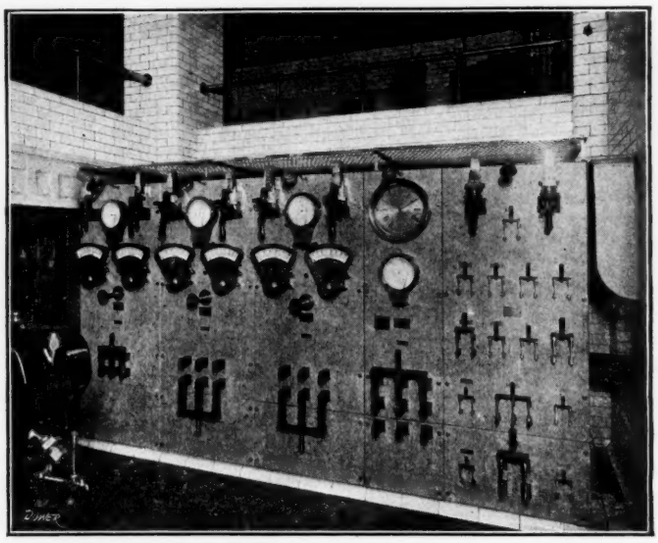


FIG. 7. CONTROL SWITCHBOARD

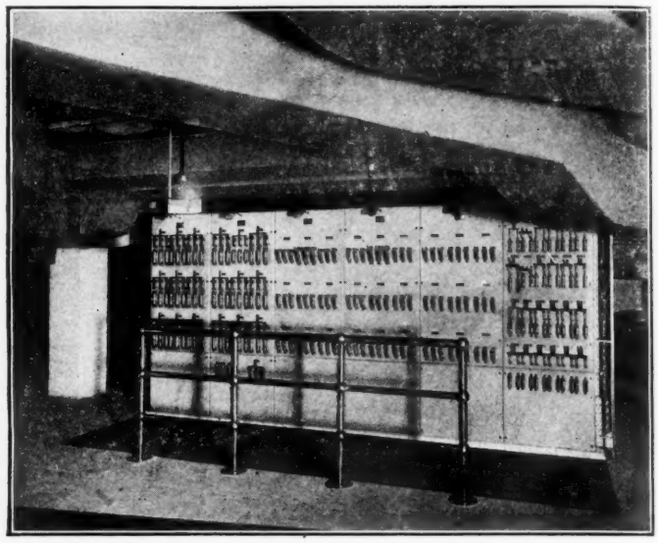


FIG. 8. DISTRIBUTING SWITCHBOARD

One passenger and one combination passenger and freight elevator, both furnished by the Otis Elevator Company, are of the automatic push-button control type. Push buttons at each floor and in the car operate the elevator. The car cannot be made to move until all the hatch doors are closed. The hoisting machinery of each elevator is driven by a 7½-horsepower motor. Two dumbwaiters, furnished by Burdette, Roundtree & Co., are operated by 4-horsepower motors. The

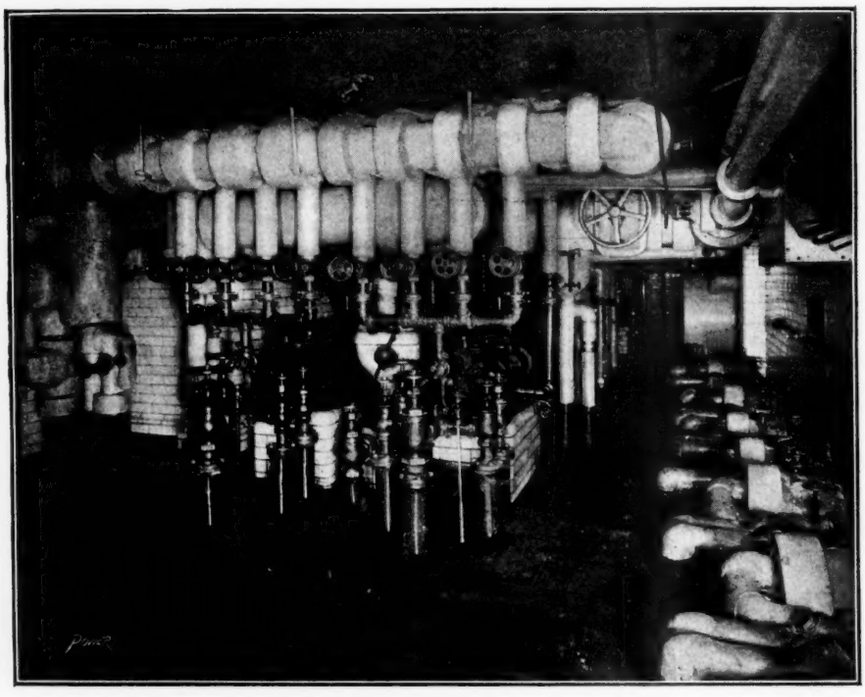


FIG. 9. A VIEW OF THE PUMP ROOM

The power plant was designed to be in keeping with the rest of the building. Each piece of apparatus which the plant contains was installed because, in the estimation of the designers, it was the very best procurable. Every reasonable precaution has been taken to insure continuity of service. An inspection of the illustrations presented herewith will serve to convince one that the external appearances are in keeping with the purpose which the designers had in mind. All walls are finished with white porcelain tile. The engine-room floor is of red shale tile and forms a very pleasing contrast with the walls and the bright work on the engines.

We are indebted to George L. Grub, superintendent of the estate, for his courtesy in extending to us the privilege of securing the material of which this description is composed. We acknowledge our appreciation of the efforts of Richard Butler, chief engineer, in assisting us to collect the information required.

Japan has recently installed the largest hammer-head crane in the Orient and one of the largest in the world. The crane, which is of 150 tons capacity, is 177 feet high and is operated by five separate motors of 50 horsepower each. The crane has a jib or arm 156½ feet long revolving on a number of cast-steel rollers. The main work intended for this crane is placing boilers, engines and other heavy machinery in position.

A Central Heating Station*

By W. A. Wolls

At a power station of the Columbus Railway and Light Company the exhaust from the engines is used in a hot water heating system which serves residences in the district. Heating service is furnished at the rate of 15 cents per square foot of radiating surface per year.

The power station of the Columbus Railway and Light Company, from which hot-water heating service is furnished, is located within the residence section in the south central portion of the area served. The location necessitates the hauling of coal by wagon and the purchase of considerable water from the city.

The station equipment consists of six 350-horsepower water-tube boilers, three of which are equipped with superheaters and chain-grate stokers. The remaining three have extended furnaces for hand firing. Two of the boilers are arranged for use as water heaters for the heating system, having all of the necessary valves and connections. A complete economizer installation is used for the heating of boiler-feed water.

TABLE 1. SCHEDULE OF SUPPLY-WATER TEMPERATURES FOR STILL-WEATHER CONDITIONS.

Outside Temperature above Zero.	Temperature Supply Water.	Outside Temperature above Zero.	Temperature Supply Water.	Outside Temperature above Zero.	Temperature Supply Water.	Outside Temperature above Zero.	Temperature Supply Water.	Outside Temperature below Zero.	Temperature Supply Water.
68	106	48	139	28	170	8	198	10	224
66	112	46	141	26	175	6	201	12	226
64	117	44	144	24	178	4	204	14	229
62	121	42	147	22	180	2	207	16	232
60	125	40	150	20	184	0	210	18	235
58	128	38	154	18	187	below zero	...	20	237
56	131	36	157	16	189	2	212	22	240
54	133	34	159	14	191	4	215	24	243
52	135	32	162	12	194	6	218	26	246
50	137	30	165	10	196	8	221	28	249

The generating equipment consists of one 250-, one 400- and one 500-kilowatt three-phase 4150-volt alternators, direct driven by horizontal, cross-compound Corliss engines, also one Parsons 1000-kilowatt, three-phase, 4150-volt turbo-generator.

For heating the water for the heating system a 5000-foot standard Alberger condenser is used, equipped with dry- and wet-vacuum pumps. All piping and valves are so arranged that the exhaust steam from either the engines or the turbine can be made to enter the condenser. Two Laidlaw-Dunn-Gordon compound duplex pumps, size 14x20x15x18 inches, are used to circulate the heating water. Each pump is equipped with pressure governors and stroke counters. One pump only is required, except in extremely cold weather.

The electrical equipment of the heating station is in parallel with that of the main generating station, thus permitting the heating station to vary its kilowatt output in accordance with the demand for heat. The turbine is operated condensing except in an emergency. The exhaust steam from the engines alone is used to heat the water for the heating system. A vacuum is maintained within the condenser-heater relative to the water temperature required; at the same time all condensed steam is returned to the boiler and no steam escapes to the atmosphere.

The temperature of the water for the heating system is regulated in accordance with the schedule in Table 1. This schedule applies to still-weather conditions only. With falling outside temperature and with a wind of 12 miles velocity or over per hour, five degrees are added to the temperatures given in the table. With a falling outside temperature and a wind of 18 miles or over per hour, ten degrees are added.

The heating-system circulating pumps are operated at pressures of from 40 to 50 pounds, gage, and considerable care is exercised to maintain the proper ratio between air and water within the air chambers. Entrance of air into the flow mains is prevented by means of large automatic air traps.

A steel tank, 72x44 inches, is used as an expansion tank; connected to it is the return main and the circulating-pump suction. A pressure of four to eight pounds, gage, is maintained in the tank.

A record of an average day's operation and output is given in Table 2.

The supply mains are laid underground at an average depth of 4 feet, incased within rectangular wood conduits constructed of rough cypress boards. The conduit is built three-ply with an intervening air space of approximately ½ inch between boards. The space within the conduit, around the pipe, is filled with oil-treated shavings. Alongside of each main conduit is laid a galvanized-iron pipe line, 2 inches to ¾ inch in size, for furnishing compressed air to be used with the thermostatic control system with which each residence is equipped. Under and parallel to each conduit is laid a 3-inch porous drain tile, provided at intervals with sewer connections. The top of the conduit is covered with a good grade of tarred felt before the trench is filled in. There are 4.1 miles of mains. They are standard commercial steel pipe in size from 12 to 2 inches. All pipes are joined together with screw couplings and all valves and fittings are screwed, except the 12-inch expansion joints. The mains are anchored at intervals of 500 feet, or less where necessary, by means of malle-

TABLE 2. RECORD OF AVERAGE DAY'S OPERATION.

	Temperature.			Degrees Drop.	Gall's Water Pumped.	Kw. Output.	Wind Velocity, Miles per Hour.
	Outside.	Flow.	Return.				
A. M. 12:00							
1:00	18	192	158	34	70,290	1,000	14½
2:00	18	194	160	34	87,862	1,250	13
3:00	14	198	164	34	94,891	1,350	15
4:00	14	192	164	28	87,862	1,250	15
5:00	12	198	164	34	87,862	1,250	12
6:00	12	198	164	34	98,406	1,400	16
7:00	12	194	166	28	82,942	1,180	14
8:00	12	196	164	32	106,704	1,520	17
9:00	12	196	164	32	94,188	1,340	17
10:00	14	194	164	30	85,050	1,210	17
11:00	18	194	164	30	98,406	1,400	16
12:00	22	194	164	30	79,427	1,130	17
P. M. 1:00	26	186	164	22	81,536	1,160	17
2:00	28	188	162	26	70,992	1,010	16½
3:00	30	188	162	26	91,377	1,300	18½
4:00	18	188	160	28	83,645	1,190	18
5:00	16	190	160	30	102,623	1,460	18
6:00	14	196	164	32	97,000	1,380	17
7:00	14	196	166	30	92,782	1,320	15
8:00	10	196	166	30	94,991	1,350	17
9:00	8	198	168	32	96,297	1,370	12½
10:00	8	198	168	30	97,000	1,380	15
11:00	7	200	168	32	97,000	1,380	11
12:00	6	200	168	32	103,326	1,470	12

*Abstract of paper presented to the National District Heating Association, at Toledo, during the meeting of June 1, 2, 3, 1910.

able-iron flanged collars one is placed on each side of a connecting coupling, and the flanges are fitted to the ends of the conduit. Pipe expansion is provided for by the use of iron-body brass-sleeve slip expansion joints, in sizes of 6 inches and larger. In sizes of 5 inches and under, the expansion is taken care of by U bends.

All valves and expansion joints are inclosed in brick or concrete manholes, which facilitates inspection and repairs. Manholes are fitted with cast-iron covers, flush with the pavement. All exposed pipe and fittings within the manholes are kept well painted with linseed oil and red lead to prevent corrosion.

Customers' services are installed by the company and charged to the consumer at the company's cost of installing. Genuine wrought-iron pipe 1¼ inches in diameter, or larger, is used for branch service. All branch lines are laid underground at an average depth of 30 inches in conduits of the same general construction as the main conduits, without the use of drain tiles. Service cocks of the inverted-plug type are located at the curb line for each service.

Heating service is furnished at the rate of 15 cents per square foot of radiating surface for a year by contract, the heat being furnished at all times when the outside temperature is below 70 degrees Fahrenheit.

At present there is approximately 205,000 square feet of radiating surface connected to the system.

An Economical Belt Drive

By Fred H. Colvin

A belt drive which was so carefully planned and installed that it has run eleven years without costing a dollar for repairs.

One of the interesting features of the shops of the F. E. Reed Company, of Worcester, Mass., is the system of belt drives which were installed nearly 11 years ago by Nathaniel Hill, of Lowell, Mass. Starting in the engine room with the 136-horsepower Brown engine with its 12-foot flywheel running 83 revolutions per minute, the whole power of the shop is transmitted by two comparatively narrow leather belts, one being 5 and the other 7 inches wide, being what is known as light, double leather belt.

Fig. 1 shows the engine flywheel and the idler above it which forces the belt to make contact with about three-quarters of the flywheel's circumference. This is for the narrow belt; the idler for the wide belt is shown in Fig. 2, where the belt also has a large arc of contact and goes around the idler shown.

Compact Dynamo Drive

Fig. 3 shows a very short coupled belt connection in the same engine room where space is extremely limited and which was necessary to drive the dynamo for furnishing light and current for the shop. This is taken from a short jack shaft carrying the large pulley shown at the extreme left of the picture, the belt making about three-quarters of a turn around it and running over idlers so as to have an equally large contact with the dynamo pulley. One idler is adjustable by

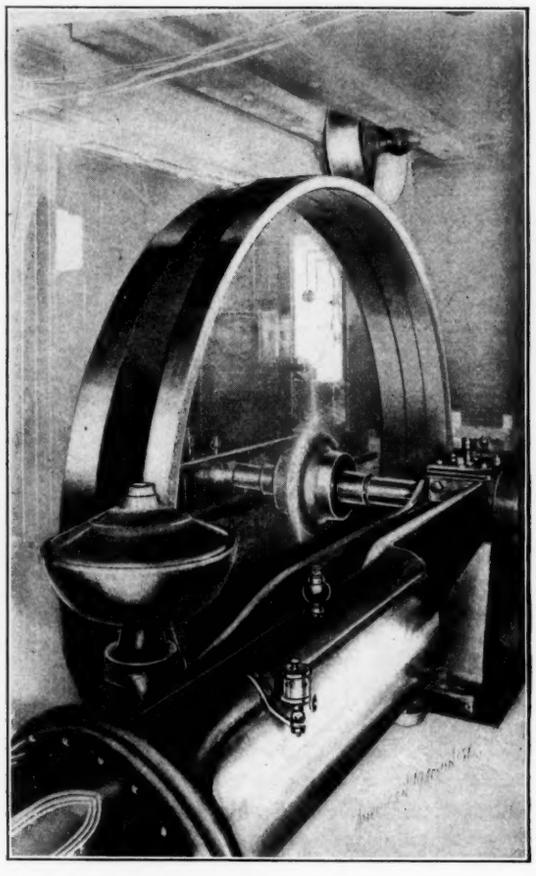
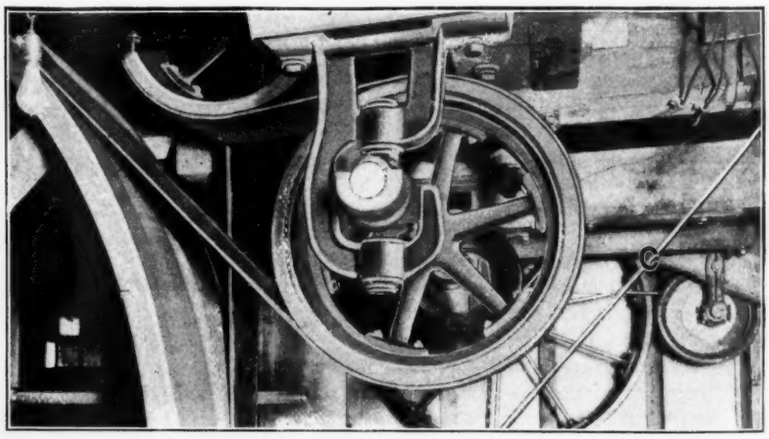


Fig. 1. Engine Room with Two Belts on the Flywheel



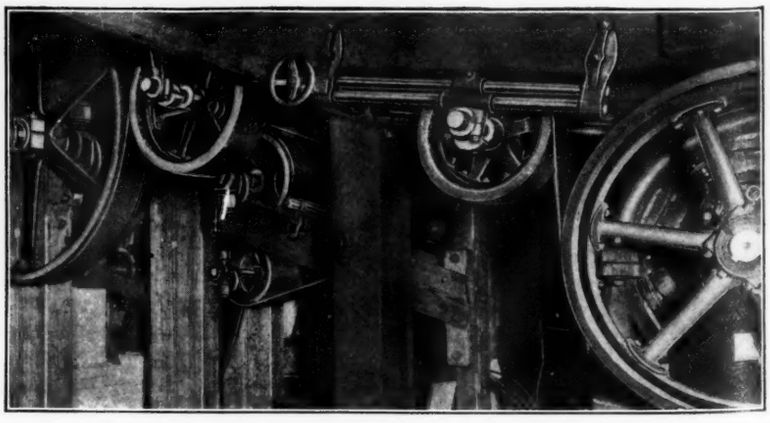


Fig. 2. The Idler on the Wide Belt
Fig. 3. Belting from Jack Shaft to Dynamo

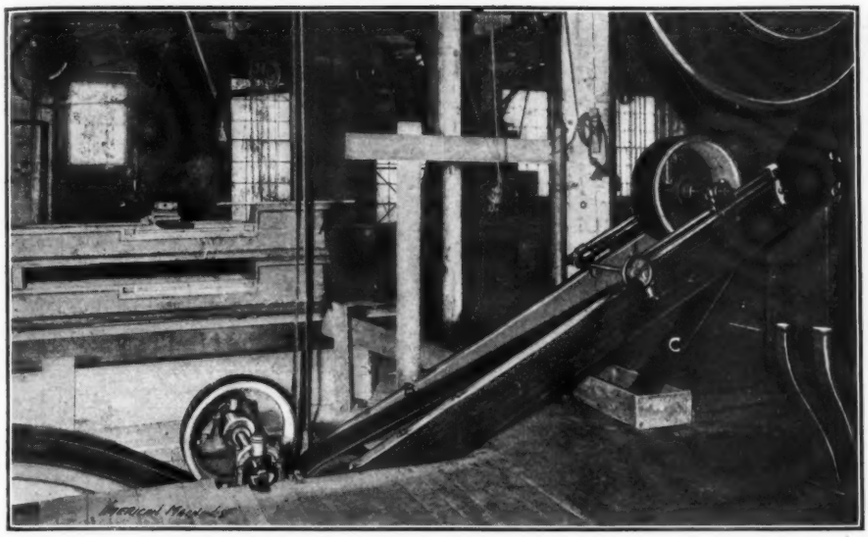


FIG. 4. WIDE BELT DRIVE THROUGH FIRST FLOOR

the screw arrangement shown so that the proper belt tension can be secured at all times. This not only allows excellent belt contact but also keeps the under side of the belt out of the way between the two timbers shown over the idler pulley.

GETTING POWER UPSTAIRS

The view in Fig. 4 was taken before the flywheel was boxed in and shows how the narrow belt goes straight up to the next floor while the wide belt *B*, after going over the upper idler in Fig. 2, runs off at an angle and drives the large pulley shown, 6 feet 8 inches in diameter, in the upper right-hand corner, the return being down through the floor as shown at *C* in Fig. 4.

Fig. 5 shows the narrow belt after it passes through the floor above and gives a good idea of the large size of driving pulleys used in the line shaft. This pulley is 7 feet 8 inches in diameter. Here again, the extremely large belt contact will be noticed and the adjustment of the idler for varying belt conditions.

In Fig. 6 is an interesting quarter-turn drive where power is transmitted down from one of the line shafts to a special department below. The angle of the upright timber supporting the idlers and the way in which they act as guards for the belt is clearly shown. There is another large pulley directly below the floor, the lower idler maintaining the same large contact as on the upper pulley.

AN INTERESTING ARRANGEMENT

Fig. 7 shows an extremely interesting and apparently complicated arrangement which transmits power from one shaft to the other, and also to the intermediate shaft which is used for a special purpose. Beginning with the right-hand shaft and following the belt in the direction of the arrow we find it goes around the large pulley up over idler *A*, around idler *B*, straight to the left to idler *C*, around this to the under side of the large pulley *D* on the intermediate shaft, and over this to the pulley on the shaft at the left. While this seems to be rather complicated it will be noticed that the large contact is secured on all three of the driving pulleys, which enables them to transmit the desired power.

Fig. 8 is a very close connected quarter turned drive which requires little explanation. The power coming up from below at the extreme left and being transmitted to the shaft at right angles, through the large pulley *A*, over the idlers *B* and *C* to the other pulley *D*. It will be noticed that in this case both sides of the belt are used, in the case of the idler *D*.

INTERESTING BELTING FIGURES

At engine speeds quoted these belts give a belt speed of about 3100 feet per minute, and dividing 136 horsepower by 12, the combined widths of the belts, we have 11⅓ horsepower per inch of width. According to these figures, they are securing a horsepower at a belt speed of a little less than 280 feet per minute per inch of width which is considerably

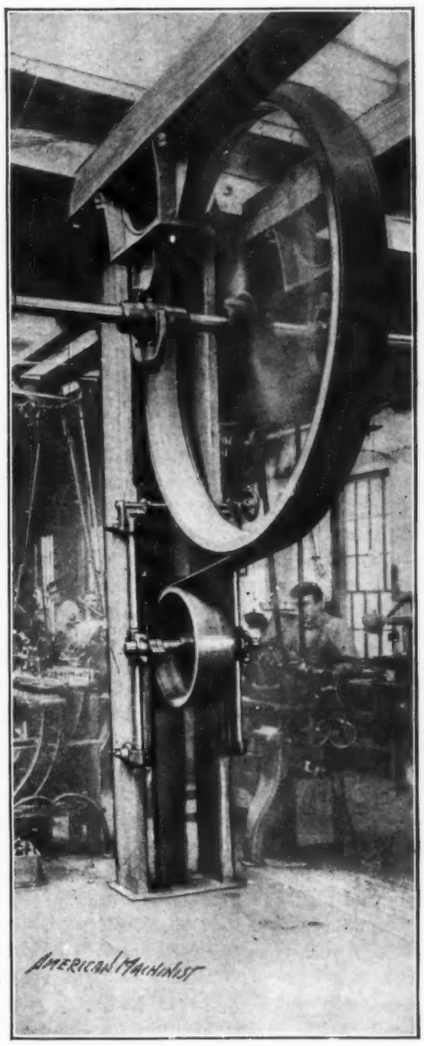


FIG. 5. NARROW BELT FOR SECOND FLOOR

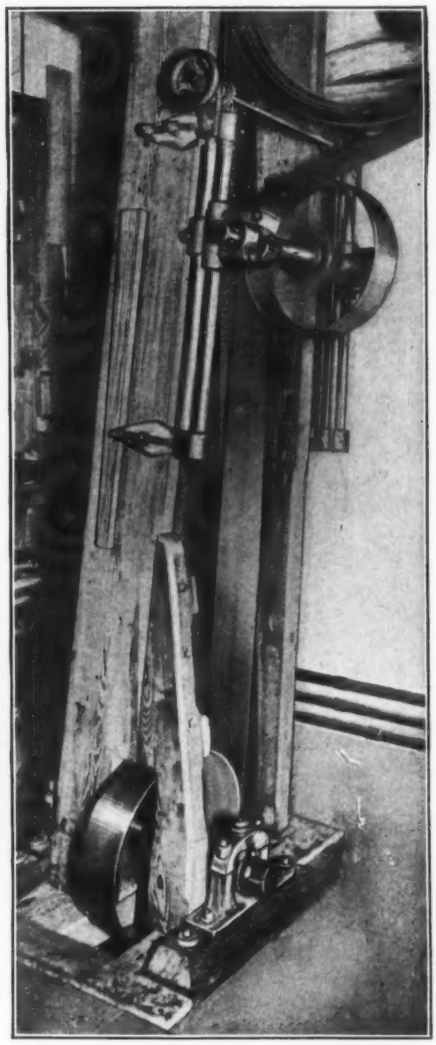


FIG. 6. DRIVING DOWN WITH A QUARTER-TURN BELT

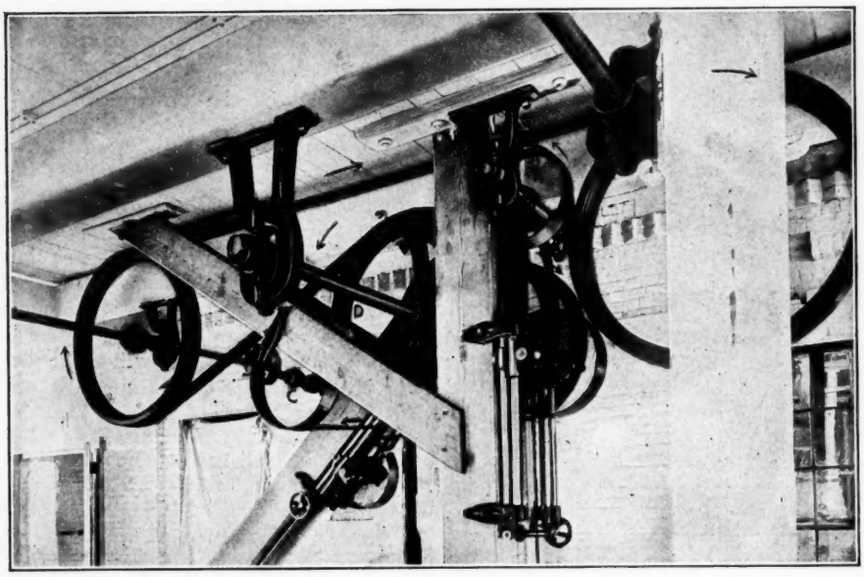


FIG. 7. CLOSE ARRANGEMENT OF PULLEYS TO SECURE GOOD CONTACT

lower than is usually considered as a safe allowance.

These belts can all be run forward or backward without running off the pulleys,

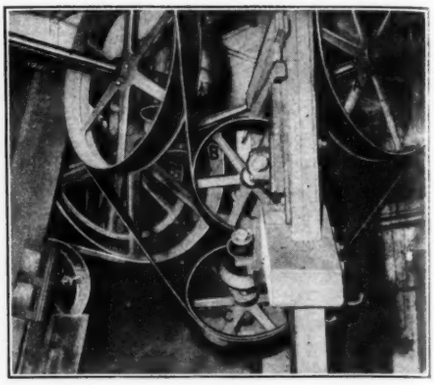


FIG. 8. REVERSIBLE QUARTER TURN

all stretch being taken care of by the screw-adjusted idlers shown. This is an extremely interesting installation in many ways, and the fact that it has been in constant operation for years with the same belt and without the expense of any kind except that required for ordinary care, speaks very highly for its economy.

Furnace Cracks and Their Repair

By W. H. Booth

One of the commonest forms of boiler trouble is the cracks which develop in the furnaces and combustion chambers. One never knows what a crack will do. Sometimes it will lie quiescent indefinitely; at other times it will extend steadily in length and will often leak freely.

The usual method of preventing a crack from extending is to drill a small hole in the plate beyond the limit of the crack but in line with it. The crack then extends forward and finally reaches the drilled hole, which will effectively stop further progress.

To mend a crack, a very common way is to rivet a patch over it. This, however, introduces the evil of double thickness with dirt between and such patches are very apt to become burned. Another method is to cut out a large section of the plate adjacent to the crack and rivet a patch over the opening. This still leaves a double thickness at the overlap, but patches of this order are the only means available if there is tension on the plate.

Where a plate is not in tension it is sometimes quite allowable to use an entirely different scheme, a form of repair that has proved very successful. A hole is drilled about 3/8 inch in diameter just beyond one end of the crack and is tapped out with a fine thread. Into this tapped hole is screwed a plug and a second hole is drilled, partly in the plate and partly in the plug. This second hole is threaded and plugged and the operation is continued until the whole of the crack has thus been drilled out and plugged. The plugs are then cut off flush with the surface of the plate and filed down smooth. Thus each plug is partly cut away and is keyed fast and prevented from turning by the adjacent plugs. Such repairs have been known to last indefinitely. But it must be borne in mind that only under compressive stress is this mode of repair practicable, for it has no holding together effect; the plugs merely serving to stop the crack and hold in steam.

Cracks often occur in the vertical parts of combustion chambers or on the part of the furnace where it joins the combustion chamber. Doubtless these plates are sometimes badly strained in the bending processes and internal stresses are set up in them. Such plates are often better after being plugged than before they cracked, for they are no longer under such severe stress. Annealing is the process required to eliminate these stresses but it is to be feared that such annealing is often neglected or is insufficiently performed so that a fracture is often only a sign that the stress has been relieved.

In a homogeneous material such as mild steel, a crack once started will extend even beyond the area of the stress which caused it. Hence the need of drilling well beyond the point to which the crack can be traced. The crack will not pass the drilled hole if the stress has been relieved sufficiently by opening the worst part of the crack.

All repairs should be carefully carried out with discretion and the method just mentioned was first brought to the writer's attention by a marine engineer of considerable experience who had successfully employed it for a number of years.

To repair a cracked furnace or other exposed part in tension, by means of riveted patches is inevitable, but such patches are often very unsatisfactory for they introduce the evil of double thickness and almost invariably there is burning of the overlap. A patch put on without cutting away the plate beneath is even worse, for it forms a blister of a most severe nature.

It was the practice at one time to stiffen weak furnaces by riveting to them closely fitting hoops of iron, but almost invariably these would give trouble. The vertical portion was maintained comparatively cold by the circulation of the water and the horizontal part was nearly as hot as the plate to which it was riveted. The expansion of this section caused great stress in the edges of the vertical web, invariably causing it to corrode. To remedy this evil the strengthening hoop was made of angle iron nearly two inches larger than the furnace to which it was fixed. This was firmly wedged into place and held to the furnace by tap bolts with nuts on the outside. By this method, water is allowed to come in contact with all parts, there is considerable elasticity combined with the arched support of the hoop and there is no differential expansion of the parts of the hoop to cause wasting as in the case of the closely attached hoop.

Is Compression Economical?

The question of the economy due to compression puzzled and interested Dwelshauvers-Dery from the very commencement of his study of the steam engine. It was largely in order to be able to experimentally investigate this question that he sought from 1870 with so much persistency and tenacity to establish steam-engine laboratories in connection with schools of engineering.

Often called as an expert to settle differences between manufacturers and users of steam engines, he had had numerous occasions to prove by experience that theory is not always in accord with practice. The question frequently put to him, "if the rules of the art had been followed," was met by him with this other question, if these self-styled rules of the art should be followed.

At the Exposition of London in 1862 he became familiar with the use of the Richards indicator on the Porter-Allen engine and took with it numerous diagrams, with the object in view of studying with particular care the action of the steam during the periods of expansion and compression. On his recommendation the illustrious Brasseur, his professor at the university of Liége, obtained a Richards indicator for the university, the first to be introduced on the continent of Europe. This precious instrument rested quietly in the mechanical museum up to the time when Dwelshauvers-Dery succeeded Brasseur in the Chair of Applied Mechanics, in May, 1868. Dwelshauvers-Dery then sought occasions for the useful employment of the instrument, his object being most frequently to prove the value of compression. The first consideration of the subject was in connection with direct-connected pumping engines. At that time there was explained in the course at Liége only what was called the "ordinary theory," based on the hypotheses: that the admission takes place at constant pressure, equal to the pressure in the boiler; that the expansion follows the law of Mariotte; that during the exhaust the counterpressure is constant and equal to the pressure in the condenser; and that there is no compression at the end of the return stroke. The diagrams taken by the indicator, however, demonstrated that all of these hypotheses were false and misleading, inasmuch as they diminished considerably the apparent consumption of steam per horsepower-hour. But he did not discover the positive laws governing the phenomena. The work of Rankine, in which he was thoroughly grounded, had habituated him to the law $pv^n = \text{constant}$, for the period of expansion, n taking different values according as the action took place with or without a steam jacket. The study of many diagrams proved to him that the exponent n was not constant.

The belief that steam is saved by compression came about not because anybody ever saved any steam that he knew of in that way, but because theory seemed to say that there should be such a saving. Professor Dwelshauvers-Dery, one of the leaders in scientific steam engineering, started in to prove that such a saving existed, and to measure its accordance with the theory. He found that the more compression he used, the less power he got per pound of steam. His work was submitted to the eminent American Engineer, Benjamin F. Isherwood, who bore out his conclusion that there was no advantage to compression other than the mechanical one of helping the engine quietly over the center.

He knew the treatise by William Pole on the "Pumping Machines of Cornwall" (Weale's "Papers on Engineering," 1849) which presents a remarkable analysis of the ascending and descending strokes and their combination, of the supposed action of the steam following the law of Mariotte, of the consumption of steam, the piston speed and the comparison of the results of computation with those of practice.

Another memoir which struck him forcibly was that of D. M. Greene on "Economy in the Use of Steam," which appeared in the *Journal of the Franklin Institute* in 1858. The author sought to bring theory into accord with a series of tests made at Erie by order of the United States Government, with the object of determining the economy due to expansion in various degrees. One there reads: "In the discussion which follows, it is supposed that the steam follows during the expansion the law of Mariotte, modified by the fact, recently discovered, that each thermal unit is capable of furnishing 772 foot-pounds of work. . . . As a necessary consequence, this transformation must be accompanied by a certain amount of condensation in the cylinder, from which it must be concluded that the volume of steam admitted at each stroke of the piston must be greater than the space generated by the piston by the volume of the steam condensed to do the work." Greene does not speak of reëvaporation, but his estimate of the cost of the work and of the loss by clearance was well calculated to set a young student to thinking.

The tests at Erie demonstrated that there exists a degree of expansion (some four or five-tenths), which corresponds to the minimum consumption. Those of D. K. Clark on "Locomotives" lead to the same conclusions. In February, 1868, Rankine published in *The Engineer* of London, a series of remarkable articles on "The Thermodynamics of the Steam Engine." It was time to introduce some novelties in the course of instruction, and it was to this task that Dwelshauvers-Dery consecrated himself. He published, notably in the *Revue Universelle des Mines*, in 1872, a "Théorie des Moteurs à Vapeur," but which was far from satisfying to himself. Since 1862 his work with the Richards indicator had abundantly proved that the theories explained in the school courses did not merit confidence. From this arose his intense desire to possess a laboratory provided with an experimental engine. It was in 1870 that he presented the proposition for the first time, and without success, to the authorities at the University of Liége. This date should be remarked, for at that time there existed nothing of the kind in the world.

The question of the economy of compression in the clearance space was connected with the foundation of this laboratory in this way: Dwelshauvers-Dery had introduced into the course of instruction at Liége in 1872 the graphostatic and the graphic methods in general. In order to demonstrate its advantages, he presented to the Association des Ingenieurs sortis de l'Ecole de Liége a paper upon this subject, in which he demonstrated the following theorem:

If the laws of expansion and of compression are the same, with a complete expansion a complete compression will annul the detrimental effect of the clearance.

In the accompanying diagram, Fig. 1, *A D E C A* is a surface proportional to the energy obtained by the use of a quantity of steam of which the volume is represented by *A D* in an engine without

clearance. If the machine has a clearance proportional to $O\,O' = G\,A$, and the steam is compressed behind the piston from the point C' up to the initial pressure $O\,A$, the volume of steam which expands on the following stroke is equal to $G\,A + A\,D = G\,D$, but the volume expended will be equal only to $A\,D$. Then a complete expansion after this compression will produce an amount of work represented by the area $A\,D\,E'\,C'\,A$. This will be equal to $A\,D\,E\,C\,A$ if the areas of the two curved cross-hatched triangles $A\,C\,C'\,A$ and $D\,E\,E'\,D$ are equal; and they will be equal if the horizontals $m\,m$ and $p\,q$ at the same hight are equal; that is to say, if the laws of expansion and compression are the same.

A colleague of Dwelshauvers-Dery criticized, not the demonstration, but the principle itself, and attempted to demonstrate analytically that the theorem was wrong even in the case of the law of Mariotte. He wrote a note upon the subject which appeared in 1873 in the *Revue Universelle des Mines*. After considerable discussion Dwelshauvers-Dery on December 13, in 1874, demonstrated that the analysis of his critic was erroneous in not taking into account the work necessary to compress the steam remaining in the clearance space, when it was the entrance of the higher-pressure steam itself and not the movement of the piston which brought about the compression.

And both were ignorant then that Zeuner had been the first to discover this theorem by the analytical method.

But Dwelshauvers-Dery, notwithstanding the evidence of his demonstration, maintained a reservation as to the exactness of the principle as applied to practice. In an unpublished note he said to his critic: "But I wish to preserve a prudent reserve because this is a question which cannot be solved theoretically in the present state of our knowledge. The heat exchanges during compression must necessarily change the law of expansion. What does this become? I have knowledge of tests, which show a notable economy, but made with too little care to warrant entire confidence. Actual tests alone can certainly resolve the question. When is it, therefore, that our equipment will be such as to permit me to make these tests in the name of our Ecole des Mines, to give to her the credit of having solved one of the most important questions concerning the economy of combustible in engines—a question which must interest to the greatest possible extent not only the mechanical engineer, but all those who are interested in industry."

This note, addressed to one of the highest authorities of the school, still left them indifferent, or rather hostile, to the creation of a mechanical laboratory. In 1873, after the Exposition of Vienna, where he had made the friendship of Thurston, Dwelshauvers-Dery went to Colmar to visit the illustrious Hirn, from whom he received the most cordial welcome. He explained to Hirn his views and his doubts, and was invited to work out his verifications experimentally on the famous machine of Logelbach. From this interview arose the tests of 1873 to 1875, made by Hallauer, Grosseteste and Dwelshauvers-Dery under the direction of Hirn, and of which Hallauer made a report to the Société Industrielle of Mulhouse in 1876.

Dwelshauvers-Dery had urged Hirn to set the valves so as to give a high compression, but the engine was not adapted

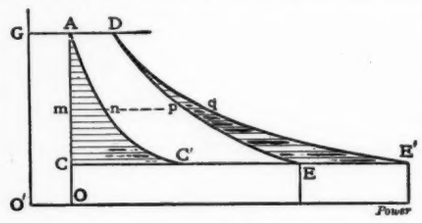


FIG. 1

to it, which led to the conclusion *that an experimental engine should be exclusively reserved for that purpose, without being restricted to any other service and should present the greatest possible flexibility for the variation of the conditions and variables of the test.* In a preface to the report of Hallauer, Hirn said: "Dwelshauvers-Dery, one of the distinguished professors of the University of Liége, expressed to me the desire to assist and coöperate in some tests upon the steam engine, carried out after the method which I have described in my last work on thermodynamics. He came to me, not only as a friend and a scholar, but was charged with an official mission in the name of the Minister of Public Instruction. Convinced that numerous and methodical tests on motors in general, and especially on the steam engine, could lead only to new progress, he had conceived a great and useful idea—to found, in connection with the university of which he was professor, a laboratory of physics and of industrial mechanics where the young men could study on a life-size scale and produce valuable and useful results even in studying.

The opposition of Liége only increased the obstinacy of our professor. Addressing himself directly to Minister Delcour, he obtained a subsidy which permitted him to have constructed an experimental machine, designed particularly with that point in view, which ran in 1880 at the Exposition of Brussels, presented by the builder, of the firm of Beer. Its dimensions were 0.3 meter in diameter and 0.6 stroke. It had the fault, for the desired purpose, that it was equipped with poppet valves, of which the opening was brought about mechanically at a position of the piston which one could mark with a great deal of exactness, but of which the reseating was brought about by the weight of the valves, and the piston, during the time of closure, passed through a space depending upon the velocity with which the valve was dropped. The degrees of expansion and compression, therefore, could not be determined with the greatest precision. However, the machine such as it was could be used to great advantage in teaching, but there was still wanting a boiler and a building, and his repeated demands fell upon deaf ears. The most that he obtained was the promise to be taken care of after everybody else had been supplied. Charles Beer, the builder of the machine, offered to him then a building in his own establishment, and Dwelshauvers-Dery bought the boiler and necessary instruments out of his private means. Thus, the exercises at the laboratory were inaugurated at the end of 1885 in the shops of Beer at Jemeppe, 10 kilometers, or 6¼ miles, from the university. In spite of the distance and the want of shelter for the observers, the students brought to their work there a courage and ardor which proved that they comprehended the importance of this sort of instruction, and they worked with an intelligence and admirable regularity which produced results.

Always possessed by the same idea to study the economic effect of the compression of the steam in the clearance space, Dwelshauvers-Dery tried on the machine at Jemeppe degrees of compression far beyond the usual, continued during 0.5 or 0.6 of the stroke, but he remarked from the first test that the diagram of the compression $C\,B\,G$, Fig. 2, presented near the end a hook $B\,G$ that was not to be explained except by assuming leaks, which must be verified at first and then made to disappear.* He tried the valves and the piston, had them all corrected, called to his aid his friend, the celebrated Walschaerts, who after numerous trials and touchings up, declared that there was not the slightest leak to the valves. The piston was then subjected to the same minute examination, and subjected to the most rigid tests, without the slightest evidence of leakage. And the hook appeared after all this, just as it had appeared before. Notwithstanding the certainty which he had that this phenomenon was not due to a fault of this particular machine, Dwelshauvers-Dery did not wish to publish the results of his tests because outside of the incompletely explained facts regarding the compression, some of the apparatus did not work to his satisfaction. For example, the jet condenser did not permit of sufficient exactness in the measurement of the quantity of water which had operated in the cylinder. For an experimental engine a surface condenser is required. Furthermore, it was necessary to perfect the brake, the

*See *Revue de Mécanique*, 1901, page 13, second semester.

thermometers, the measuring vessels, etc. He took note of all these faults and planned a new establishment which would realize the best conditions, as indicated by experience.

This time his hope was not frustrated. Thanks to an energetic intervention of the former Minister Frére Orban and of a new rector, Roersch, the government consented to bring the laboratory within the locus of the University of Liége in 1890, and to allow a small credit to improve the engine and the instruments of observation. Hirn, who had done a great deal to bring this about, did not have the pleasure of witnessing the final triumph, which did not come after all until after the erection of mechanical laboratories in a multitude of schools.

As soon as the laboratory of Jemeppe had been transferred to Liége and the new engine erected and regulated, Dwelshauvers-Dery set himself to the work of determining the constants of the machine and the instruments, a work much more considerable than one would imagine who has never done it. He made provisions for observing to 0.1 of a millimeter the positions of the piston at the commencement and the end of each phase of the stroke, and from each end for any distribution whatever it might be. The measurement of water by circular and rectangular orifices, according to the hydraulic head, the calibration of the planimeters, thermometers, etc., and of the springs of the indicator, were made the object of the greatest care. He published the part of this work which would be useful to scholars in a volume entitled "Donneés relatives à la Machine du Laboratoire de Liége." It will there be seen that the machine was provided with a surface condenser, with a balance for weighing the water coming from the condensation of the steam, and with a tank for measuring the condensing water; that it was fitted with three separate jackets, one at each head and one about the barrel of the cylinder, each with its automatic trap and its gaging vessel; with a trap and its measuring vessel at the steam chest; with a double slide valve at each side of the cylinder for admission of which the commencement and the end could be regulated independently at will, and for the exhaust two separate slide valves, also equally adjustable. On each end of the cylinder an indicator, of which the reducing motion accomplished by eccentric, crank and pins, reproduced exactly and with the use of very little cord the position of the piston. It was characteristic and unique. When the piston was at 0.1 of the stroke, the pencil of the indicator was exactly at 0.1 of its course, and so on throughout. In this way could be marked with exactness the points where the different phases commenced and ceased. With a long flapping and stretching cord, this operation could not be carried out with any degree of exactness. There was further an apparatus for calibrating the indicator springs by weighting them directly while hot, a mercury manometer and an independent superheater.

One of the characteristic features of the organization of Dwelshauvers-Dery's laboratory was the means of measuring, with a great degree of exactness, the weight of steam acting in the cylinder at each stroke of the piston, or at each revolution if the two strokes of the piston are equal. For this purpose it is

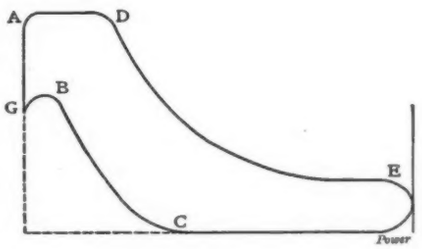


FIG. 2

necessary that during the observations the conditions should remain as constant as possible, and it is necessary also to be able to verify the constancy and regularity of these conditions. For this purpose the engine was run several hours before the commencement of the regular observations, and the signal to commence the record was not given until the director was assured that uniform conditions had been established. The most of the observations were taken in such a way that the test could be divided into sections of about one-quarter of an hour each, furnishing in this way a check upon the test. An automatic signal announced the moment when there had been discharged from the air pump a predetermined weight of water, for example, 50 kilograms of condensed steam, which had operated in the cylinder; and the observer noted at each signal the time and the number upon the revolution counter. This operation, to be a little more explicit, is conducted as follows:

The condensed steam discharged by the air pump is received in a large flask, placed on the platform of a steelyard and furnished with a cock, which remains open until the regular observations are to be taken. At the desired moment, the engine being in full operation, the director of the test gives the signal to close the cock, and notes the number upon the revolution counter and the time. He then puts the moving weight upon the beam at a point where it will balance at the desired weight, and when a sufficient amount of water has entered to balance it, the signal is again sounded, and the revolution counter and time noted. During all this time the indications of the revolution counter have been noted for each minute. At the same time the weight is placed so that the bell will announce a new weight of water in the flask, for example 50 kilograms, and at the signal he marks again the time and the indications of the revolution counter. This operation is continued for equal weights of 50 kilograms until the end of the test.

From the table of his observations, the experimenter can easily determine if in each period of 50 kilograms the number of turns and the time are approximately the same, and choose for the duration of the test the sum of the successive periods where the greatest regularity has obtained, determining thus the total duration of the test and the total number of revolutions, the average time occupied by the stroke, and the average consumption of steam per stroke can be obtained.

The machine is provided with a Weyher & Richmond brake, of which the pulley is constantly cooled by a current of water, of which the quantity and inlet and outlet temperatures are measured in order to have another check.

One could have, therefore, at Dwelshauvers-Dery's laboratory as much, if not more, exactness in the results of a test as elsewhere in all the essential respects; the determination of the position of the piston in its stroke, of that of the pencil of the indicator, the points where the different phases of the cycle commence and finish, the pressure of the steam in the cylinder and in the boiler, the quantities of water acting in the cylinder in the form of steam or in the condenser for condensation, the number of revolutions and conditions the constancy of which is constantly verified, the observations continuing every two minutes for the most part.

For these reasons those who have wished to throw discredit on the Dwelshauvers-Dery tests have found nothing to say, if it was not that the machine was leaky, which was absolutely not the case. This will be admitted when the precautions which had been taken are considered, and when it is remembered that Dwelshauvers-Dery himself believed them at first to exist.

Let us next see what it is that led his critics astray.

It has already been explained that with high compression the diagram shows at the end of the compression line a hook, coming from the fact that at a certain moment the increase of pressure commences to diminish. Then the pressure stops increasing and later falls away. From the study of these diagrams Dwelshauvers-Dery found that this phenomenon was due to the condensation of the steam against the walls of the cylinder at the end of the compression, and a positive demonstration of this was made by George Duchesne, and by the fact that the Leavitt machines at Louisville, which certainly had no leaks in the piston,

showed a hook in the indicator diagram similar to that mentioned. George Duchesne substituted for the condensable steam in the cylinder of the Dwelshauvers-Dery engine noncondensable air and compressed it to the same degree, and the hook was not formed. Dwelshauvers-Dery's detractors had not a leg left upon which to stand (*Revue de Mécanique*, 1901, second semester).

But let us get to the tests themselves on the economy due to compression.

To get his hand in and to train his personnel Dwelshauvers-Dery made a number of tests between 1894 and 1896, of which the reports appeared in the *Revue Universelle des Mines*, etc. Then he published an account of his entire method of experimenting in the *Revue de Mécanique*, Tome 1, 1897, pages 7, 218, 432, and finally there appeared in this same *Revue*, Tome 1, page 925, his first report on his tests with high compression. He commenced by quoting the opinion of Marcel Deprez, the well known French engineer, upon the tests of Bauschinger, made in 1870, and without much accuracy, on locomotives—and for that reason without doubt reputed practical—and indicating an economy of 22 per cent. in favor of compression. He then explained the theorem of Zeuner: *With complete expansion, complete compression annuls the detrimental effect of the clearance, providing the law of compression is the same as the law of expansion.*

"This," said Dwelshauvers-Dery, "is the principle which it is necessary to verify experimentally, and which is of the first importance; for if one can by compression to the initial pressure annul the detrimental effect of the clearance, no matter what its magnitude and what the speed of the engine, the constructor is in possession of a very simple means to economize steam and is not obliged to strive for exceptional means of construction for reducing the clearance." We quote here from the writings of Dwelshauvers-Dery at that time. "During the month of March last we made, with the assistance of our pupils, eight consumption tests, of which four had 0.1 and four 0.2 compression, counting that the economy due to compression would be sufficiently marked as between the two. The engine operated noncondensing at about 5½ atmospheres of pressure. With the actual proportions of the clearance space the admission to 0.1 ought to give us a condition of practically complete expansion, and it would require, it seemed to us, in the neighborhood of 0.3 compression to arrive at compression to the initial pressure. With the compression of 0.3, however, and only 0.1 admission, the area of the diagrams became so small that the pupils, as yet untrained, would have found it difficult to measure them. It was for this reason that the experiments did not go beyond a compression of 0.2. Following our custom, each test made with the pupils had been preceded by a preliminary test, with our personnel, in order to assure ourselves that all was in order, and the machine was put into operation at 9 o'clock in the morning, while the official test did not commence until half past two. In this way plenty of time was available for this preliminary arrangement.

"The results of these tests were exactly the opposite from what we expected. The 0.2 compression was found to be more expensive than 0.1. Before searching the reason for this it appeared prudent to establish it solidly, and for this reason we arranged to repeat the tests with our corps of trained assistants and several students who had shown exceptional ability, with 0.3 compression and also without compression. They confirmed fully the first results and permitted us even to establish by means of a diagram the law of augmentation of consumption, due to the augmentation of compression. Doubt was no longer possible. It was necessary to search an explanation of the fact. Our diagrams of exchange presented it to us with perfect positiveness, and we will reconsider them here.

"In the ordinary operation of engines the live steam coming from the boiler is partially condensed against the confining walls during the admission. This phenomenon occurs from two reasons: because the live steam comes in contact with a cooler metal, and because it must compress and reheat the stagnant steam resting in the jacket at the moment when the admission valve is open. It has received the name of *initial condensation.* It is this initial condensation, accompanied by a very energetic call for steam from the boiler, which causes all the trouble, which deranges all the provisions of a self-styled theory which does not take them into account, which puts an abyss between such theories, so learned as they are, and the practical theory of Hirn, which does take them into account in the fullest possible measure. All the palliatives employed to ameliorate the cycle and diminish the consumption have the same and unique effect of diminishing the initial condensation.

"After admission the water coming from the initial condensation is entirely and completely reëvaporated by the heat furnished by the containing metal during each complete cycle. Of that reëvaporation a part is favorable; that is, that which takes place during expansion; the other is lost, and on that account expensive. It is that which takes place during exhaust. This last can be annulled considerably by the employment of a steam jacket concurrent with an appropriate ratio of expansion. Superheating may have the same result.

"The compression produced by the piston, having for its effect the elevation of the pressure of the steam inclosed in the clearance, has equally that of elevating at the same time the temperature of the steam and that of the walls, and, in consequence, of diminishing the initial condensation during the admission. This fact is demonstrated by our tests, which have on this point confirmed our expectations.

"During the compression itself, however, the disturbing action of the cylinder walls makes itself felt. In order to heat up the walls the compressed steam is partially condensed. There is produced a condensation anticipating admission, which is joined to the initial condensation to produce the deleterious effect. *It is the sum of this anticipatory condensation and the initial condensation which measures the cause of the prejudicial action due to the metallic walls.* In our experiments this sum, of which one part—the initial condensation—was diminished, increased rapidly with the degree of compression, because the anticipatory condensation increased still more rapidly.

"Having thus a good idea of the physical rôle played by compression, we also wished to determine the influence of the size of the clearance and of piston speeds. For this purpose we first placed on the faces of the piston, plates which reduce the space between the piston and the piston head from 11 to 3 millimeters. Its volume, which had been 7.9 per cent. of the volume generated by the piston per stroke, was reduced to 6.6 per cent. The consumption of steam was hardly diminished. The compression had continued to produce its effects without much attenuation and following the same law.

"In our first series of tests we were not able to compress the steam to the initial pressure. In the new series, with the reduced clearance, we hoped to do so, but the condensation, especially near the end of the compression, became so energetic that the diagram, instead of continuing to mount, terminated by recurving toward the base abruptly at the end, forming a hook. We had operated only in two ways, without compression, and with 0.3 compression. We pushed the compression to 0.4, always with the same lack of success.

"The steam at its entrance had a temperature in the neighborhood of 200 Centigrade (390 degrees Fahrenheit). With a superheat in the neighborhood of 45 degrees Centigrade (81 degrees Fahrenheit), the speed controlled by the load upon the brake was around 45 revolutions per minute. The governor was not in operation, the operator at the brake maintaining the speed constant by that means alone. Tests were then made at 60 revolutions per minute, following always the same method, but we did not obtain a final pressure superior to that of admission even at 0.4 compression.

"The method of Hirn has been fol-

lowed in the study of all the tests, with a view to determining first the anticipatory condensation under the designation R_c; second, the initial condensation under the designation R_a; and finally the total condensation $R_c + R_a$; fourth, the consumption of steam per horsepower-hour. The results are seen in Figs. 3 and 4.

"At 45 revolutions per minute the consumption per horsepower-hour increases from 16.196 kilograms for 0 compression to 25.435 kilograms for 0.4 compression, 57 per cent. of difference.

"At 60 revolutions the consumption increased from 14.910 for 0.1 compression to 24.470 kilograms for 0.4, or 65 per cent., as shown in the diagrams.

"The initial condensation diminished in proportion as the compression increased, as shown by the curve *E F*, but this diminution is slow; on the other hand, the anticipatory condensation R_c curve *C D* increased rapidly as the compression was augmented, so much so that the total condensation $R_a + R_c$ (curve *E G*) augmented rapidly also as the compression was increased."

A study of these tests has also demonstrated that compression commences by superheating the steam, and that it does not cool enough to condense until near the last tenth of the stroke. This fact, although duly established, has been called into question by inexperienced theoreticians.

George Duchesne, pupil and assistant of Dwelshauvers-Dery, gave the irrefutable proof of this later, and at the same time showed that the existence of the final hook was due to rapid condensation and not at all to leaks of piston or valve, as M. Boulvin had claimed in an article to the *Revue de Mécanique*, which appeared in June, 1898. The tendency of this article was principally to throw discredit upon the experiments of Dwelshauvers-Dery in assuming that his engine had leaks and faults contrary to ordinary practice. M. Boulvin had never seen that machine, had never determined the magnitude of its leaks. He judged it solely by what had been published and principally by the diagrams. He had never seen a hook at the end of the compression line. But Dwelshauvers-Dery had put into the hands of the illustrious experimenter Isherwood all the documents relative to the tests on compression, with the original diagrams. Mr. Isherwood had studied these in the light of his wide experience and had assured himself, first of all, that the engine had no leaks. He assured Dwelshauvers-Dery of this. But he gave also an explanation of the effects of compression other than that of the action of the walls. He concluded that if compression augmented the consumption per indicated horsepower-hour it was because in the tests the indicated horsepower had diminished, while the absolute work, friction neglected, had rested constant, while that of the resistances increased with the compression. There was an opinion worthy of respect, to which Dwelshauvers-Dery gave satisfaction in his new test.

But to come back to the supposed leaks and to the studies of George Duchesne. At first he assured himself that the hook of the diagram was not due to a leak of the piston, thinking nevertheless that if the leak existed when it was the piston which compressed, it would not lack any the less when it was the steam which did the compressing. To this end instead of compressing condensable steam he compressed noncondensable air, and the final hook disappeared from the diagram. It was, therefore, evident that the hook was due to the condensation, the cylinder wall having become cooler than the compressed vapor at a certain moment.

He then studied compression diagrams by a method until then unknown, requiring diagrams of exceptional precision, such as those afforded by the tests of Dwelshauvers-Dery. A memoir which appeared in the *Revue Universelle des Mines* of 1899 under the title "Essai sur la Théorie Physique de la Machine à Vapeur," a second in the *Revue de Mécanique*, July, 1899, under the title "Etat de la Vapeur à la fin de l'Emission." We will review the latter here.

In the experimental theory of Hirn, as Dwelshauvers-Dery had explained it, notably in the Encylopédie Leauté, 1888 and 1892, there was a single doubtful point concerning the weight of steam left in the clearance space at the end of the exhaust, or at the commencement of the compression. Its volume and pressure were shown by the diagram and in the steam tables could be found the weight per cubic meter, and thus the weight of steam supposed to be dry and saturated and occupying the same volume. But is the steam saturated, or moist, or superheated? In the case of its being moist, what is its quality; that is to say, what the proportion of the steam to the total weight, and in the case of superheat, what is its temperature, which must be known before its density can be determined? The error could but have a considerable bearing upon the results of the analysis, and it was necessary to formulate an hypothesis upon the subject, and that hypothesis was no less necessary to the study of the real experimental diagram furnished by the indicator than for the entropy diagram, cumbersome and traced by the hand of man. Hirn assumed that the steam at the end of the exhaust was saturated and dry, believing that this was the most probable condition; but he often said to his friend Dwelshauvers-Dery that it was the study of high compressions which would bring about the real solution. It is there in effect that George Duchesne found it, and in this way.

From among the best of the diagrams he chose the average of the test of

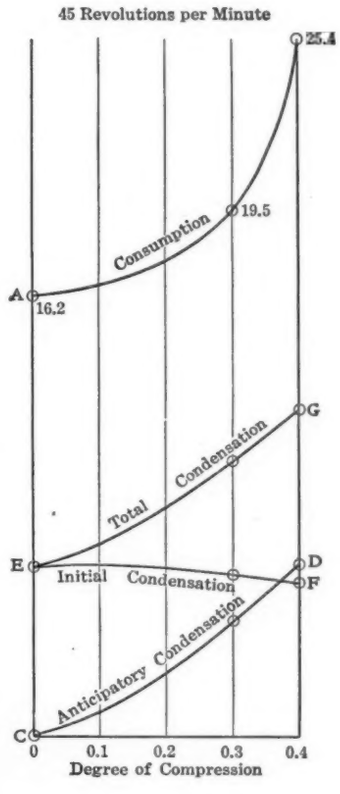


FIG. 3

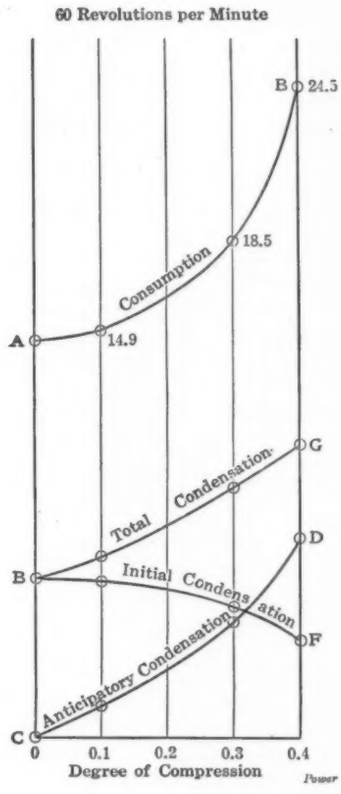


FIG. 4

September 16, 1897, of which the data had appeared over the signature of Dwelshauvers-Dery in the *Revue Universelle* in 1898. He reproduced the compression line upon a larger scale *A A₁ B C G D E*, Fig. 5. From *A* to *A₁*, the end of the exhaust stroke, the pressure is constant and 10,192 kilograms per square meter. From *A₁* the throttling of the steam causes prematurely a small rise in pressure which increases up to *C*, where the exhaust valve is entirely closed. From this point on the pressure varies along the curve *C G D E* during the compression. Such are the fundamental experimental data, besides which it is, of course, understood that we have the volume occupied at each instant by the steam.

George Duchesne studied the diagram under three assumptions. First, that the steam at the point *C* was very moist; second, that it was nearly dry and saturated; third, that it was superheated. In the first case, in order to carry the analysis to an extreme in that direction he assumed that the fluid shut in and compressed consisted of 75 per cent. water and 25 per cent. steam; in other words, that its quality was only 25 per cent. It was contrary to the assumption of Hirn, and might furnish a means to check it.

Upon the first assumption he traced from the point *C* the adiabatic *C D F*, which at first runs below the curve *C G D E* traced by the indicator and then approaches it. From *C* to *G* the indicator curve lies further and further above the adiabatic, which represents compression as it would occur without exchange of heat between the fluid and the containing metal. It appears, therefore, that up to this point the metal is giving up heat to the steam, but from *G* to *D* the actual curve approaches the adiabatic, even crossing it at *D*, showing that the steam is then giving up heat to the cylinder walls. At *G*, following the curve of the indicator, the temperature is 138 degrees Centigrade, and as the direction of the heat exchange is reversed at this point, the fact is established that at the point *G* the steam and the cylinder walls are at the same temperature, 138 degrees.

"Our hypothesis would, therefore, lead to the conclusion that during more than one-half of the return stroke, at a pressure of 10,192 kilograms per square meter, and at a saturation temperature of 99.6 degrees, the water must have lain without evaporating on metal at 138 degrees Centigrade.

"It appeared equally improbable that a quantity of water corresponding to a quality of 0.25 would be entirely disseminated throughout the mass of steam, and even less with this steam inclosed within walls of a higher temperature.

"Let us go a little deeper into the subject and trace in the diagrams *H I J K* the temperature of the steam along the indicator curve, and at *H L* the temperature of the steam along the adiabatic, and in *M N O P R Q*, a diagram of which the ordinates measured from the base line *M R* represent at each instant the exchange of heat. It will be seen that from *M* to *P* steam will have taken up nearly 23½ calories, which it will have given up between *P* and *R* in a time only one-third as long, since the distance *M P* corresponds to an angle described by the crank nearly three times that which corresponds to the distance *P R*.

All of this indicates the rejection of the hypothesis that the steam contains 75 per cent. of water at the commencement of the compression.

M. Duchesne plotted the diagram of the variations of volume of a kilogram of steam operating under pressure. This curve met that of the indicator at a certain point, beyond which the steam changed from a condition of superheat to saturation, and then moisture. It showed besides a maximum departure from that of the indicator at another preceding point, beyond which several circumstances particularly favored the flow of heat from the steam to the metal.

First, the temperature of the steam increases in proportion to the compression; it differs, therefore, more and more from that of the walls. Second, in approaching the center the movement of the piston becomes slower and slower the time

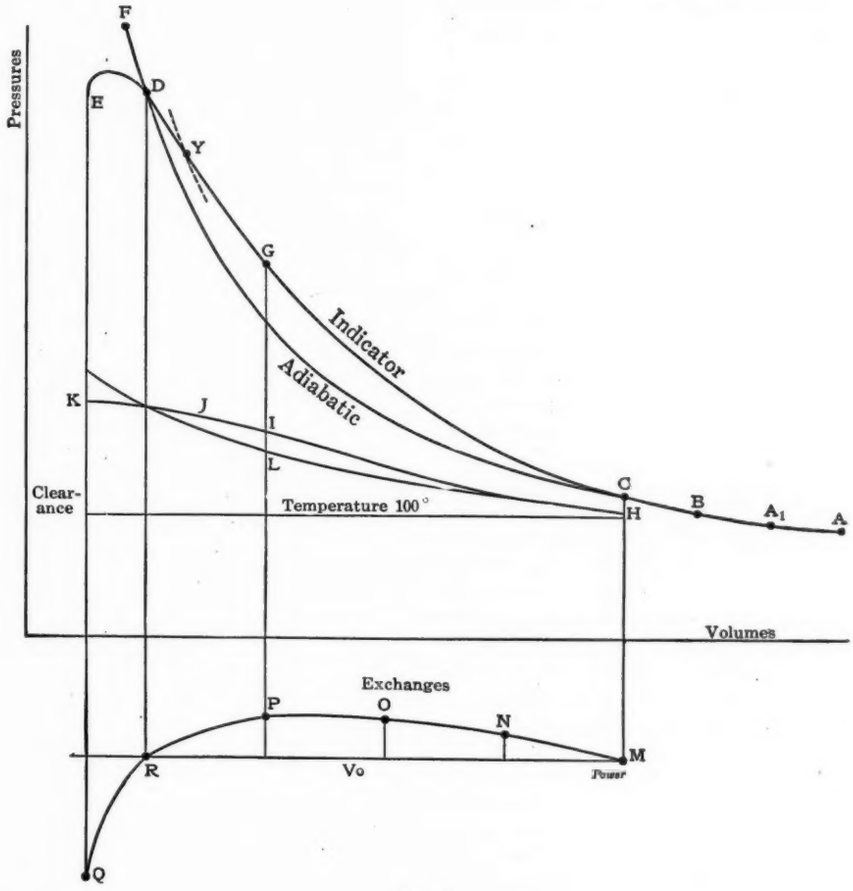


FIG. 5

"Let us make another examination of moist steam, but assuming this time the much higher quality of 0.965 at the commencement of compression," says George Duchesne, and he demonstrated that we should arrive at the same results; that the hypothesis was as unsound in this case as in the other. He then examined another case where the steam was dry and saturated, but with a tendency to superheat, or even with superheat of a fraction of a degree. In this case the temperature of the steam, at first a little high, attained and then exceeded that of the cylinder walls, and under these conditions the superheat rendered the exchange of heat insignificant.

for the exchange of heat is increased, and in consequence the intensity of that exchange. Third, beyond the point of maximum separation of the two curves as these approach, the steam tends toward a state of saturation, and on that account abandons its heat more easily. The indicator diagram shows a point of inflection, corresponding to a sort of break in the diagram of heat exchange.

The diagram from the indicator presents two singular points: one a little before the commencement of the compression, which is an abrupt change of curvature, and the other near the end, which is a point of inflection. The hypothesis of Hirn renders a complete

account of these singularities. First, at *B*, Fig. 5, the steam passes from the state of saturation to that of superheat through throttling, and at the point of inflection *Y*, the pressure-volume curve of saturated steam meets the indicator diagram and proves that from a state of superheat the steam passes to that of saturation. As soon as a drop of liquid is formed on the walls, the condensation goes on with great rapidity. This, George Duchesne demonstrated very positively by an experiment related in a memoir published in July, 1899, in the *Revue de Mécanique*.

His conclusions are:

First, when in the cylinder of a steam engine the steam is saturated and the walls wet, the steam, the water and the metallic surface in immediate contact with the water become nearly instantaneously of the same temperature.

Second, if the wall is dry, it may be at a temperature above that of the steam.

Talented experimenters had expressed the opinion that indicator diagrams could not be made with sufficient precision to confirm the deductions which Dwelshauvers-Dery and George Duchesne had drawn from them. In response, the latter published in August of 1900 in the *Revue de Mécanique* a memoir explaining the precautions which had been taken to assure the proportionality of the abscissas of the diagram to the displacements of the piston and that of the ordinates to the steam pressure.

For the abscissas with the ordinary reducing motion, with long cords which can whip and stretch, the objection has a real value, but the reducing motion at Liége is rigid. A system of eccentric and connecting rod, geometrically similar to that of the crank and connecting rod of the engine, puts into motion a rigid shaft connected to the paper drums of the indicators. Means are provided on this sliding rod for the attachment of the indicator cord, which is only a dozen of centimeters in length, and all distortions are, therefore, negligible. There does not exist a more positive reducing motion. With a vernier giving the position of the piston at least to 0.1 of the millimeter, the verification of the abscissas of the diagram shows the greatest perfection that can be obtained in practice, it being understood, of course, that the bearings are not worn and that there is no lost motion.

So far as the ordinates are concerned, the objections bear upon the accuracy of the springs and their calibration, and on the momentum of the piston and other moving parts of the indicator. M. Duchesne explains how Dwelshauvers-Dery proceeded by testing the indicator hot and loading the piston successively with equal weights, placed delicately and directly upon it, and then removed, each position of the pencil being marked by the pencil of the indicator. If the points traced in loading did not coincide with those traced in unloading, or if the points were not all equally distant, the spring was rejected. For an elongation of the spring it was necessary to reverse this process, preserving the same position on the paper. This calibration absolutely independent of the scales furnished by the makers of the indicators was frequently renewed in order to insure against inevitable deteriorations. Those who have tested them in this way know how rarely the scales furnished by the manufacturers can be depended upon. As to the momentum of the piston, that is to say the acceleration of the masses of movement of the Richards indicator used at the laboratory of Liége, its influence cannot be denied. That which was necessary was to measure or to estimate it, and George Duchesne did this with a laudable minuteness. He even measured the friction by direct weighting and found that altogether, weight of the parts, acceleration and friction, amounted to a difference of not more than 0.527 millimeter in the ordinates, the scale being 840 kilograms per square meter per millimeter of ordinate. The error could, therefore, not attain 440 kilograms per square meter, and he concluded that: "These differences cannot, therefore, modify our conclusions on the subject of the state of the steam at the end of the exhaust.

"In spite of the most minute precautions the operation of a steam engine is never perfect. Two diagrams are never identical. All of them, however, lead to the same conclusions. What, then, is the significance?

"A theory of the steam engine, be it what it may, necessitates the consideration of a homogeneous fluid, and yet this is not the case. The state of superheat and the temperature of the steam vary in different parts of the mass.

"But one factor is constant in all the points of the working mass—the pressure. One can assure himself of this by taking on the same paper a series of diagrams at the same time that the indicator cock is closed little by little.

"The pistons of the indicators used on the machine at the mechanical laboratory of the University of Liége had a diameter of 20 millimeters. The pipe which leads from the interior of the cylinder to the piston of the indicator is straight and smooth when the cock is open. Its diameter is uniformly 14 millimeters, without irregularities. Its length is 80 millimeters. The influence of the restriction of the passage commences to show itself on the diagram when the opening of the cock has been reduced to one-third of its normal value.

"Under these conditions the transmission of the pressure between the steam cylinder and the cylinder of the indicator is surely more involved than between two other points. At the same moment the pressure is, therefore, as we have already said, constant in all the points of the working mass.

"Let us cite also in favor of this proposition a remark of M. Anspach, *Revue de Mécanique*, August, 1899, that two indicators installed simultaneously on the cylinder and on the *revelateur* gave identically the same pressures. The indicator furnishing data independent of its position possesses a preponderant advantage over the other instruments of investigation, which inform us only upon the state of the steam that operates in the instrument itself. It permits us to arrive at a knowledge of the homogeneous fluid assumed by the theory, a fluid which would act as does act the heterogeneous fluid which really exists, and the information which it procures for us is in consequence the more valuable in practice and construction."

The part taken by the celebrated engineer Isherwood was the most illuminating of any in the widespread discussion that the experiments of Dwelshauvers-Dery on compression aroused. "His engine must be leaky," said the inexperienced, because the end of the compression line presents the celebrated hook. In a note on page 647 of the *Revue de Mécanique*, second semester of 1898, Dwelshauvers-Dery said: "Well, this hook, which is not rare, is also a peculiarity of the engine which consumes the least steam of all the engines of the world—that installed by Mr. Leavitt at Louisville. The tests of Mr. Dean show a consumption of about five kilograms of steam (see Volume XVI, *Transactions* of American Society of Mechanical Engineers). Mr. Isherwood, the eminent engineer-in-chief of the United States navy, the most fertile of the experimenters of the past forty years, who has had in hand all my diagrams, with all the details of my method of operation, wrote to me on the 11th of August, 1898—"I have carefully measured and analyzed all the diagrams which you have sent me, and I declare that they do not show the least indication of leakage. On the contrary, their measurement proves that there is no sensible leak. I have examined them from this point of view, since their receipt, in order to satisfy any doubt upon that point before undertaking any long calculations upon them."

After this Dwelshauvers-Dery did not concern himself with the accusations of leaks uttered with so little consideration. On the contrary he turned his attention to the interpretation which Mr. Isherwood had given to the conclusions of his tests. This is developed in the letter appearing in the *Revue de Mécanique* of 1899, first semester, page 396 *et seq.* It is not in the thermal action of the cylinder walls that one should look for the loss which is attributed to compression, but in the fact that the consumption is considered with reference to the indicated horsepower, diminishing as the

compression increased, instead of to the absolute work which would be practically constant, whatever the compression. "And one will find," says he, "that be the compression more or less it will not affect the economy." He added:

"There is a practical advantage in not using compression from the point of view of the dimensions of the machine; on the other hand, it is practically very important to have a cushion of steam to avoid the shock at the end of the stroke. All practical engineers are in accord that compression is mechanically, not economically, necessary, and that it does not affect the economy, and this general opinion is sound and judicious." In citing for the first time this opinion of Mr. Isherwood, Dwelshauvers-Dery added a note: "In 1883 M. Hillereau had clearly announced as general facts those which my experiments have discovered, and he gave to me then the same explanation which I found thirteen years later." (See the *Bulletin Technologique* of July, 1898, No. 7, page 590 *et seq.* of M. Pierre Guedon.) On March 10, 1899, Mr. Isherwood added (See *Revue de Mécanique*, 1899, first semester, page 397):

"I would add here two deductions from the diagram. First, with no matter what degree of expansion and compression, and no matter what clearance, there is neither economy nor loss in compression. In any case the quantity of steam compressed will reproduce on the following stroke exactly the work of compression. Second, the compression does not modify in any way the detrimental effect of the clearance. The effect of the clearance on the steam economy is exactly the same whether there is or is not compression, or whatever the degree of compression."

In the *Revue de Mécanique*, 1900, first semester, page 5, Dwelshauvers-Dery publishes an account of 25 tests, made 10 without compression, 10 with 0.4 and 5 with 0.6 of compression, following the views of Mr. Isherwood thus expressed: "If my theory is correct, experiments like yours made with a variable amount of absolute work, following the degree of compression in such a way that the indicated work remains the same, should give the same consumption whatever the degree of compression." It was this that Dwelshauvers-Dery wished to verify by his experiments of 1899 which have shown that Mr. Isherwood was right without vitiating the results of his tests of 1897 and 1898. The tests were not easy to institute, and above all it was important to make a judicious choice of those which had been the most successful. There were used only those which sustained successfully all the methods of checking suggested by Hirn.

The average consumption of steam per horsepower-hour indicated was as follows: 11.116 kilograms without compression; 11.127 kilograms with 0.4 compression; 11.273 kilograms with 0.6 compression.

One can, therefore, say with Mr. Isherwood that practically the consumption of steam per indicated horsepower-hour is materially the same, whatever the compression, when the indicated horsepower remains the same.

Dwelshauvers-Dery concludes his memoir as follows: "The examination of these tables shows that the action of the walls increases slightly, the same as the consumption, in proportion as the compression is increased. The sum of the anticipatory and initial condensations, however, augments positively as 38.66, 41.88, 43.09 per cent., according as there is no compression or 0.4 or 0.6 of compression. If the detrimental action of the cylinder walls augments thus with the degree of compression, there must be some compensation at the end of the count, because the favorable action of the walls—restitution during expansion—also augments with the degree of compression in such a manner that the sum, or definite action, equalizes itself, or nearly so, varying from 15.67 per cent. to 18.42 and 18.24 per cent. It should be remarked here that our engine was regulated in such a manner that without compression there was no lead, while with compression there was nearly one-twentieth. Our conclusion is that the indicated work remains the same and, the pressure alone varying, the degree of compression is, so to say, without influence on the consumption per indicated horsepower, that the detrimental action of the cylinder walls during the compression and admission increases considerably with the compression, but that the augmentation is nearly compensated by the restitution during expansion."

The *Revue de Mécanique*, of 1901, second semester, has published a paper by MM. Armand Duchesne (brother of George) and Dwelshauvers-Dery on "The Laws of Expansion and of Compression Compared," which presents a great deal of interest to those who have preconceived notions upon the subject of the economy of compression, and relatively also to the accusations of leakage, of which the experimental machine of Liége had been the subject. It commences thus:

"The theorem asserting that the deleterious influence of the clearance space is annulled by a compression to the initial pressure when the expansion is complete also is not established except for the case where the law of the compression is the same as that of the expansion. It is not applicable to steam engines, because in these the law of compression is altogether different from that of expansion, without doubt on account of the thermal intervention of the metallic walls. This assertion, if not new, still lacks the experimental and decisive demonstration which we desire to present here.

"Having studied from the diagrams of the steam-engine indicator the laws of expansion and of compression to various degrees and under different conditions, we have found that the laws of compression are similar under all the cases of various degrees of compression, of operation with and without the condenser, with or without the jacket, and that it is the same with the laws of expansion for various conditions, but that these two laws differ absolutely between themselves.

"The law of expansion has been frequently presented under the well known form

$$pv^{\alpha} = constant$$

"This law can be verified on an indicator diagram when one knows the volume of the clearance relatively to the volume generated by the piston, the position of the line of zero pressure, and the scale of the indicator, and the initial volume V_o, with the initial pressure P_o.

$$pv^{\alpha} = P_o V_o^{\alpha}$$

whence

$$\alpha = \frac{log.\ P_o - log.\ p}{log.\ v - log.\ V_o}$$

"For a given indicator diagram the values of P_o and V_o are fixed and given by the conditions at the commencement of the expansion and the compression. A series of volumes v are then selected, and for each value one measures the pressure p on the diagram. Finally, for each of these terms of the series one calculates α, of which one traces the diagram.

"The comparison of the diagrams of α in the case of the expansion and of the compression makes it very evident that these operations follow totally different laws (see Figs. 6 and 7). The variations in the quality of the steam and those of the heat exchanges between the fluid and the metal lead exactly to the same conclusions."

These diagrams confirm the conclusions of George Duchesne on the subject of the state of the steam at the end of exhaust, *Revue de Mécanique*, 1901, second semester. At the end of the exhaust the metal is dry and the vapor rather superheated than simply dry. At the commencement of compression it is superheated by the effect of the work exerted upon it and by the small amount of heat which is furnished to it by the metal. Then comes a moment when its temperature attains and passes that of the metal, which it now begins to reheat, losing at first its own superheat and leading to the formation of a drop of water. From the moment of that formation of the least particle of water on the metal the law of the exchanges changes abruptly, the exchange becoming very rapid. These facts afford a complete ex-

planation of the final hook of the compression and an absolute refutation to those who attribute the final hook to a leaky piston.

The same paper gives the diagrams from the engine of the laboratory of Liége, compressing a condensable vapor and making the hook, and then noncondensable air, in which case not the least hook is formed, Fig. 8, which proves absolutely that the piston of the experimental engine at Liége was without sensible leakage when the tests of Dwelshauvers-Dery were made.

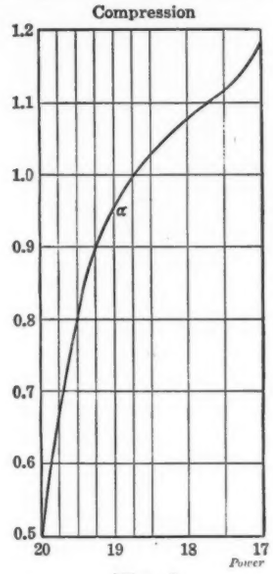


FIG. 6

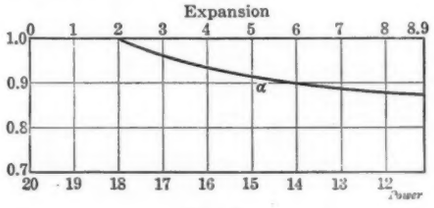


FIG. 7

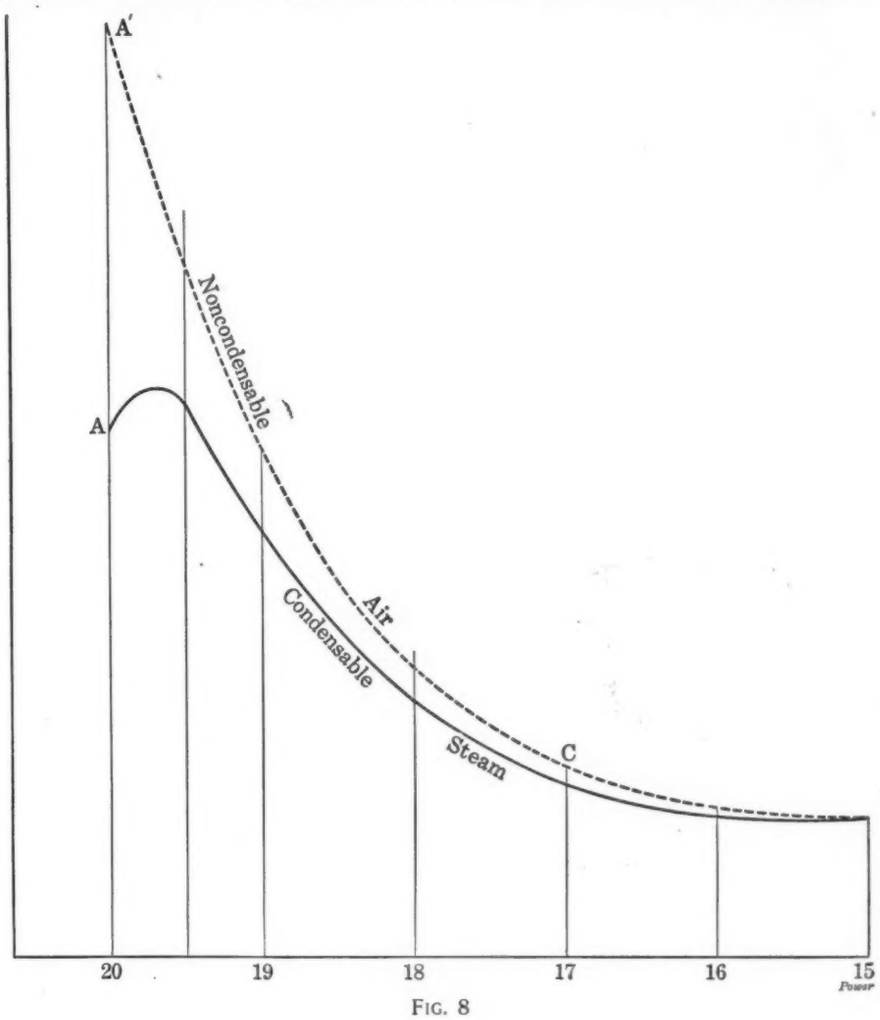


FIG. 8

It is certain that in the study of compression one should follow the indications of Mr. Isherwood and compare the consumption with the total rather than the indicated work. But even if this is done, it will be found that the compression turns out to be expensive on account of the exchanges of heat between the inclosing metal and the working fluid.

The quantity of steam furnished by the boiler at each stroke of the piston diminishes in proportion as the compression by the piston is increased, and is reduced to its minimum when that compression is complete; only the piston has had to do for itself two things which the steam would in any case have done directly if compression had not been effected by the piston—that is, the work of bringing the steam in the clearance space to the pressure of admission, and the heating of that steam and of the inclosing metal up to the temperature of the admission. Will these two effects cost more when it is the steam itself which produces them directly than when the piston is placed as an intermediary to produce them by borrowing steam or heat from the boiler? Intermediaries are always expensive, and in general it can be said that work is a poor method of producing heat units. To take up lost motion and wear and to avoid the shock at the end of the stroke, a certain amount of compression is to be recommended and will be the more useful the greater the velocity of the piston; but it should not be carried to excess, or it will become detrimental to economy.

Locomotive Safety Valves

A committee of the American Railway Master Mechanics' Association on Sizes and Capacities of Safety Valves for Use on Locomotive Boilers, reports in favor of the formula

$$Area = \frac{0.08 \times HS}{P}$$

as against

$$Area = \frac{0.10266 \times HS}{P}$$

proposed by a former committee. A number of observations have been made on locomotives in passenger service provided with safety valves the combined outlets of which would take care of from 3.64 to 4.06 pounds of steam per square foot of heating surface per hour, and no cases were found where the safety valves failed to properly relieve the boilers. The locomotives on which the investigations were made carried 200 pounds gage pressure, had 4231 square feet of heating surface and 56½ square feet of grate area. The committee's formula allows for the evaporation of 4.1 pounds of steam per square foot of heating surface, while the formula proposed by the earlier committee allows for 5.28 at 200 pounds gage pressure. In the formula proposed the area is in square inches, the heating surface HS in square feet and the pressure P in pounds absolute.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

The Right Type of Induction Motor

By R. H. Fenkhausen

When considering the application of electric-motor drive to any type of machine, the prevalence of alternating-current supply in all except the more congested districts, and the rugged simplicity of the polyphase induction motor will usually lead to the selection of this type of machine.

Broadly speaking, there is but one kind of service to which induction motors cannot be adapted and that is in service requiring a constant speed other than the normal speed of the motor, under varying loads. Lathes and boring mills are examples of this class of service; when

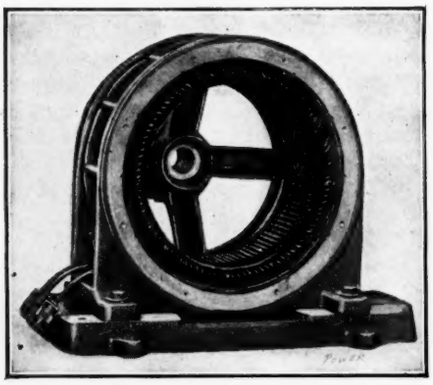


Fig. 1. Form-wound Stator

induction motors are used to drive them, speed changes should be obtained either by change gears or by cone pulleys. The questions of voltage, phases and frequency are usually governed by the available current supply and do not come within the scope of this article, which is intended to cover only the speed and torque characteristics of the various types of induction motor.

Great care must be exercised in determining the proper capacity of a motor for the work to be done, because too large a motor not only means a considerable loss of efficiency, but a far greater loss due to low power factor. The power factor of any induction motor varies with the load, and at partial load is very poor; it therefore follows that a number of partly loaded induction motors have a very bad effect on the entire system, not only causing poor regulation but decreasing the useful load which the generator can carry.

The same type of stator is used for all classes of induction motors, the different types varying only in the rotor construction. Different manufacturers use different constructions, however, and modern motors may be divided into two general classes; those with open slots and those having partially closed slots.

In the open-slot construction, machine-wound coils, insulated before being placed in the slots, are used, as shown in Fig. 1. An insulating trough is usually placed in the slot to improve the insulation and also to prevent loose laminations from cutting into the coils while they are being driven into the slots. The coils are held in place by fiber wedges. This type of construction facilitates repairs, and is practically preferable whenever the necessity for continuous operation warrants the additional first cost.

In the partially closed slot construction, the coils are hand wound and placed in the slots one turn at a time. Fig. 2 shows this kind of a stator. The taping of the projecting parts of the coils is done by hand after the coils are in place, but owing to the small space available it is difficult to make the taping tight enough

Fig. 2. Stator with Partly Closed Slots

to exclude the oil which is bound to be spilled on the windings sooner or later. Repairs to this type of frame are comparatively difficult to make, but it possesses the advantages of lower first cost and slightly better power factor.

For industrial-plant service, the principal requirement is continuous operation, because in this class of service a shut-down of one hour would often cost more than the saving due to low first cost and better power factor combined. It is therefore bad judgment to regard a slight improvement in operating characteristics as of more importance than ease of repair and mechanical strength.

Constant Speed and Moderate Starting Torque

For all constant-speed service which does not require great starting torque, the simplicity of the squirrel-cage type of rotor renders it most suitable. The low resistance of this type of rotor makes its slip at full load very low. The speed

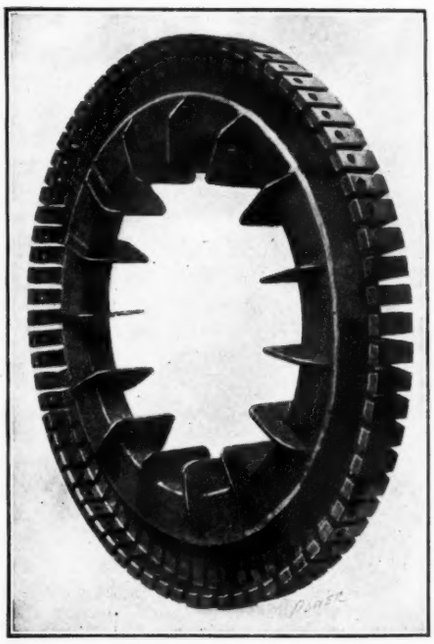


Fig. 3. Slotted Ends of Rotor Bars

regulation under varying loads is therefore very good. Its starting torque, however, is comparatively low, unless a large starting current is drawn from the line, but as the characteristics of this type of motor are largely governed by the cross-section of the rotor end rings, a change in these rings will often improve the performance of the motor. A decrease in the cross-section of the end rings will give the motor a better starting torque for the same current, but will increase the slip at full load and therefore impair the regulation and efficiency of the motor. Fig. 3 illustrates an expedient for decreasing the effective area of the rings, consisting of saw cuts between the rotor bars. Care must be taken that

all saw cuts are of the same depth, to avoid unbalancing the rotor pull.

An increase in the cross-section of the end rings will decrease the slip at full load and improve the regulation and efficiency; but owing to the low starting torque this is not advisable except in cases where the motor starts unloaded and very close speed regulation is essential.

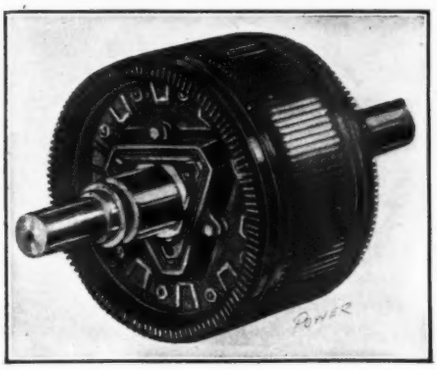


FIG. 4. STARTING RESISTANCE MOUNTED ON ROTOR

There are three methods of securing the rotor bars to the end rings, each of which is meritorious for some particular class of service. These are bolting, soldering and riveting.

For planing-mill service where heavy overloads are the rule, the bolted construction is best. In service of this type the rotor often becomes hot enough to char the paper insulation of the rotor bars. The renewal of this insulation is an easy matter when the bars are bolted, but is quite difficult if they are soldered or riveted.

For gear drives, or where there is much vibration, the bolted type of rotor is hard to keep tight, as the bolts loosen up and excessive heating occurs between the bars and end rings. The soldered type of rotor is well adapted for this class of service, except in cases of extreme overload, which might cause the solder to melt.

The riveted type of construction is somewhat of a compromise between the bolted and soldered types; it is not so liable to loosen under vibration as the bolted type or to be damaged by overloads as the soldered type, and it is easier to repair than the latter. The riveted construction should not be used where either vibration or overloads are apt to be excessive.

CONSTANT SPEED AND HIGH STARTING TORQUE

As the torque of an induction motor varies with the secondary (rotor) resistance, the low resistance of the squirrel-cage rotor limits its starting torque. For service requiring high starting torque combined with moderate starting current, therefore, the wound type of rotor is best adapted. Rotors of this type are "wound" either with copper bars or with several wires in parallel, connected to form a three-phase "star" winding, the three terminals of which are connected to the starting period to give the necessary torque and limit the starting current. The order that the full-speed efficiency and regulation may not be too low, and sufficient resistance is inserted during the starting period to give the necessary torque and limit the starting current. The starting resistance may be mounted on the rotor spider, as in Fig. 4, or may be separate from the motor. In the latter case the rotor winding is connected to slip rings, as in Fig. 5, and brushes bearing on these are connected to the resistance.

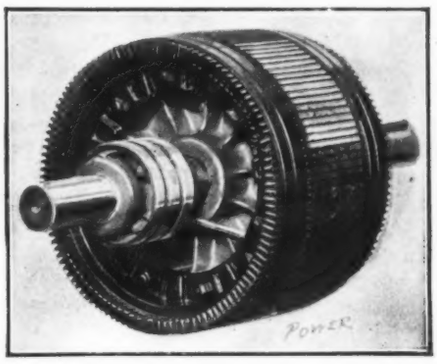


FIG. 5. SLIP-RING ROTOR

When the resistance is mounted on the rotor spider, a short-circuit of minimum resistance is assured at normal speed, as no brushes, controller leads, etc., are in circuit after the resistance is cut out. There are several disadvantages in this method, however, the principal one being the liability of starting the motor with all the resistance cut out, in case the operator forgets to pull out the handle on the motor before closing the line switch.

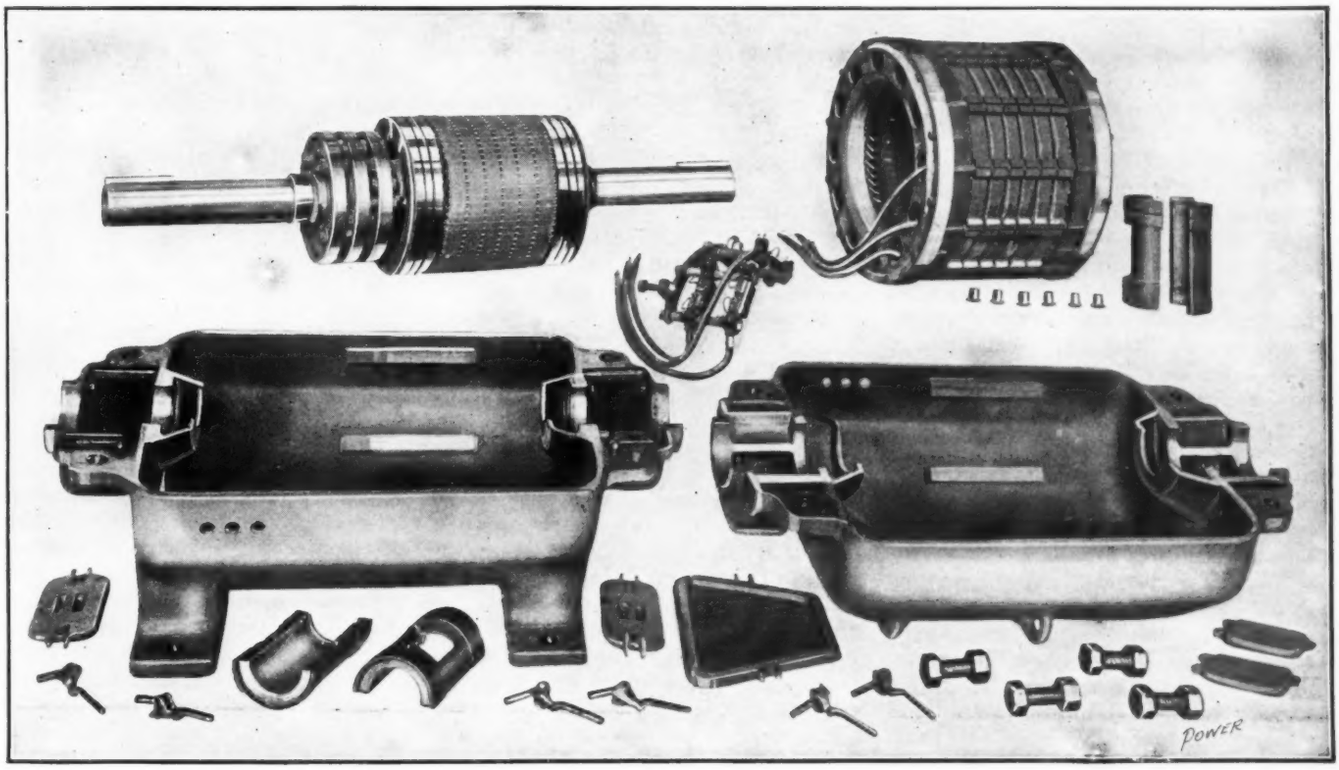


FIG. 6. DISASSEMBLED PARTS OF A MILL TYPE MOTOR

Remote control of this type of motor is very difficult, because the starting lever is on the motor itself.

Another objection to the location of the resistance within the rotor structure is the heat developed during the starting period, which adds to the operating temperature of the motor for awhile. This objection, however, is not important except when long and frequent starting periods are necessary.

When the starting resistance is external to the rotor, the motor may be controlled from a distance and, as the line switch and resistance switch are usually mechanically interlocked in the controller, there is no danger that a careless operator may start the motor with the starting resistance cut out. The objection to this arrangement is that the contact resistance of the brushes, the controller fingers and the leads from the controller to the slip-ring brushes are in circuit at all times, and with the large secondary currents employed often seriously impair the efficiency and regulation of the motor, especially if the controller is located some distance from the machine.

A short-circuiting switch may be employed at the motor, but this renders the motor liable to being started with all the resistance cut out if the operator does not open the switch after stopping the motor.

Varying Speed Service

Motors for service requiring different speeds are always of the wound-rotor type, but the character of the winding depends on whether the machine is intended for continuous or occasional operation at reduced speeds.

Continuous operation at reduced speeds requires rotors wound to a high resistance, the winding usually consisting of machine-formed coils arranged like those of a three-phase armature. Motors of this type require large magnetizing currents, their full-load slip is very high and their power factor, efficiency and regulation very poor. Their torque, however, is enormous and as torque is the principal requirement in service of this class, and the motor is usually operated intermittently, the poor operating characteristics do not constitute a serious objection to its use.

Motors designed for normal operation at full speed and only occasional operation at reduced speed have wound rotors of comparatively low resistance, the winding usually consisting of copper bars or straps. The maximum torque of this type of motor is much lower than that of the previous type, but the power factor, efficiency and speed regulation at full speed are almost as good as those of the squirrel-cage motor; at reduced speeds they are poor. This type of machine differs from the constant-speed machine designed for high starting torque only in the external resistance. For constant-speed service the resistance is proportional for starting duty only, whereas for varying speeds the resistance is called upon to carry current for long periods and is therefore made heavier.

Reversing Motors

For reversing service a motor having a rotor of small diameter and great length is necessary to minimize the disadvantage of flywheel effect. In Fig. 6 is shown a motor designed for reversing service in rolling mills. The type of outer frame that has become standard in railway practice has been closely followed, and accessibility and ease of repair are features of this construction.

All reversing induction motors are of the wound-rotor type with the exception of the high-resistance squirrel-cage type used to some extent in crane service. There are, of course, many places where a constant-speed squirrel-cage motor with standard auto-starter is equipped with a double-throw switch to enable the motor to be started in either direction, but such equipment can hardly be placed in the reversing-motor class. There is also danger that the motor may be damaged in case a careless operator should throw the reversing switch without returning the auto-starter to the off position, unless the two are interlocked.

Mechanical Features of the Load

Before selecting a motor for any given service, careful consideration of the mechanical characteristics of the load is essential. A typical application of motors requiring great care in the selection of the proper type and size is that of direct-driven fan blowers. Contrary to the positive type of blower the power taken by the fan blower increases when the discharge resistance is decreased. Therefore a motor properly proportioned for a blower discharging into a pipe of one diameter and one length will be overloaded if the discharge goes into a pipe of larger diameter or less length. Several cases have come to my notice in which motors driving blowers have been burned out by moving the blower sets nearer to the work, the decrease in the length of the piping allowing such an increase in output as to seriously overload the motor. In alternating-current service a rise in frequency may easily play havoc with a fan-blower motor because the motor speed varies directly as the frequency and the power required by the fan varies as the cube of the speed. A 10 per cent. increase in the frequency (and consequently the speed) would therefore result in a 33 per cent. increase in motor load, which would be quite sufficient to cause trouble.

When totally inclosed motors are ordered for damp or dirty locations the builder makes allowance for the lack of ventilation by using a larger size motor, but it frequently happens that motors rated for open-frame service are inclosed after purchase, and when the motor overheats on its rated load, the manufacturer is unjustly blamed. Care should therefore be used that some well meaning employee does not place a box over the motor to protect it, and thus cut off its supply of cool air to carry away the heat.

Protection From Lightning

The Committee on Protection from Lightning (B. E. Morrow, chairman) in its annual report to the National Electric Light Association, presented at the St. Louis convention, repeated the recommendation, made last year, as to the use of pipe grounds in preference to plate grounds; the pipe ground is considered more effective, especially for line work. For station protection, a number of scattered grounds offer the best protection; these, the committee believes, should also be of the driven-pipe type, and if scattered, may accomplish much better results. Some of the manufacturers of lightning arresters have standardized certain methods of connecting and installing pipe grounds. The most common of these consists in driving one or more 10-foot lengths of galvanized pipe into the ground, leaving approximately 6 inches exposed. The ground wire is fastened to the pipe by soldering or by some form of mechanical joint. Care should be used to make the path to earth as direct as possible.

It is important that grounds be tested periodically to insure their continuity. Particular attention should be given to them at the beginning of the lightning season and at time of protracted drought. Such tests should be made preferably from a low-voltage source of power, such as a lighting transformer. A pipe ground should have a resistance from ground wire to an adjacent water pipe of 15 to 30 ohms.

Secondary distributing lines should be grounded in order to minimize the danger from lightning to apparatus on the customers' premises.

General practice in station equipment shows the value of several types of lightning arresters working in multiple; for example, the multigap for ordinary disturbances and auxiliary-horn type for surges. In certain cases the use of special arrangements of horn arresters has effectively passed off disturbances that otherwise would have been expected to damage seriously the standard protective apparatus. However, on account of the possibilities of this type of arrester setting up disturbances in the system, its general use cannot be recommended. This is particularly true of systems which are partially underground. The multigap arrester has been giving good service, particularly on moderate voltages, but has its natural limitations. For instance, while

it is sensitive and effective in taking care of momentary disturbances, it cannot be expected to discharge continuously for long periods, as in the case of accidental ground on a normally ungrounded circuit.

The most practical method thus far found for protecting overhead lines from insulator failures and damage due to lightning has been by shielding them with grounded wires strung above them. A single steel cable strung well above the center of the operating lines, grounded at frequent intervals, has proved effective. Ground wires on either side of the line are probably an additional benefit, especially near stations; but the added expense of such construction must be considered in each case.

On tower lines, the overhead wire should be grounded at every tower, and on pole lines at least every 200 or 300 feet. The pipe form of ground above mentioned is recommended.

Some form of lightning rod should be extended several feet above the overhead ground wire at each of the points where it is grounded. Where an overhead ground wire is not used, it has been found that even a small grounded conductor, running from a point near the top of the pole to the ground, tends to prevent the splitting of poles by lightning.

The committee emphasized the advisability of keeping accurate records of all line troubles, disturbances, damage to protective apparatus by lightning, etc., and included in its report a system of blank forms for keeping such records.

LETTERS

Mr. Roberts' "Shunt" Connection

Referring to E. H. Roberts' low-voltage trouble, described in the issue of May 31, I would like to answer the editor's query as to why the tape burned off the german-silver shunt with an open field circuit by asking another: Why should an open shunt field circuit cause the test lamp to burn at full candlepower?

I think both Mr. Roberts and the local electrician mistook the series field winding for the shunt field winding. The series field circuit, opening at a time of heavy load, would cause all the current to pass through the german-silver shunt, destroying the insulation, which was not needed anyway.

W. J. BAILEY.

Bedford, Ind.

Before offering any explanation of Mr. Roberts' trouble, I would say that he is probably in error as to the shunt field circuit being opened by this loose connection, and if he makes further examinations he will ascertain that it was the series field circuit which opened. The fact that the connection was made up of a copper bar 1x¼ inch shows that it was a series field terminal that he found unbolted, as the shunt field connections are usually quite small; a No. 10 or 12 wire is generally used, this circuit usually taking less than 5 amperes.

The series field winding and its shunt strip are in parallel, and when the bad connection in the series field circuit opened up, the current had but one other path, and that was through the series shunt strip. This, being of high resistance, no doubt became red hot with full-load current passing through it, and burned the tap. With the series field winding out of circuit the field excitation at full load was not enough to produce sufficient flux to maintain full voltage, and consequently the voltage dropped.

T. A. LEES.

Quincy, Mass.

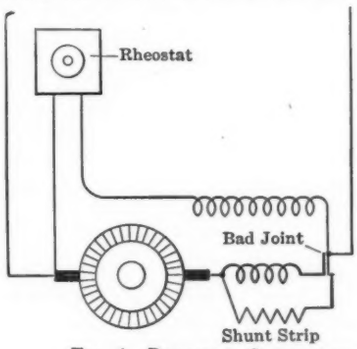
Judging from the size of the machine (35 kilowatts at 110 volts) and the size of the bar connection between coils (1x¼ inch), I am of the opinion that the series field winding was confused with the shunt field winding by Mr. Roberts. Instead of a loose connection in the shunt field circuit it was a loose connection in the series field circuit which finally developed into an open circuit. When this occurred the machine operated as a plain shunt generator which will drop its voltage with increase in load. It also diverted the entire current of the machine (which normally was divided between the series field and the german-silver shunt) through the german-silver shunt alone, causing it to overheat and burn the tape.

P. JUSTUS.

Cleveland, O.

[Substantially the same explanation as the foregoing has been sent us by V. L. Ballou, Shirley, Mass.; Adolf Bierent, Pleasanton, Cal.; B. W. Bissell, Lafayette, Ind.; H. B. Brand, Brooklyn, N. Y.; C. V. Glynn, Hershey, Penn.; R. James, Shelburn, Ind.; Ferdinand Oppenheimer, Baltimore, Md., and H. L. Wade, Los Angeles, Cal. The explanation is obviously correct. An open connection in the shunt field circuit could not affect the shunt strip of the series field winding unless the generator were operated in parallel with others and with no fuses or circuit-breakers. However, as Mr. Lees and Mr. Justus point out, it is inconceivable that the shunt field winding of a 35-kilowatt machine would be fitted with any such connection as a ¼x1-inch copper bar; this would be capable of carrying about 400 amperes, while the shunt current of such a machine could scarcely exceed 20 amperes and would be about 6 or 8 amperes in a machine of average efficiency.

It seems evident that the clamped connection from which the bolt was missing happened to be the one to which a shunt field terminal and a series field terminal were both attached, somewhat as indicated in Fig. 1, if the connections were "long shunt," as they doubtless were, or Fig. 2, if "short shunt." This is doubtless what misled Mr. Roberts into thinking that the faulty clamped connection affected the shunt field winding, and the editorial note following Mr. Roberts' letter was intended as a hint to this feature of the "trouble."—EDITOR.]



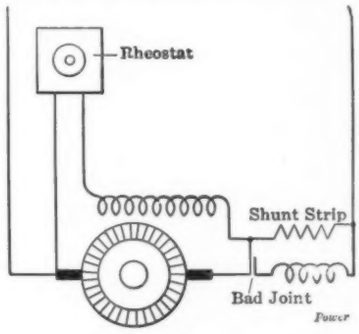


FIG. 1. POSSIBLE CONNECTIONS OF MR. ROBERTS' GENERATOR. FIG. 2

Mr. Carlton's Fuse Puzzle

In the May 3 issue, E. L. Carlton shows a diagram of two generators connected in parallel and asks why the fuse blows on the lamp circuit when the other machine is thrown in.

I believe that he will find that the main switch jaw of the machine *G2* on the positive side did not close at the same instant as the jaw on the negative side, and that this allowed a heavy current to flow momentarily around through the fuse *F* by way of the lamp circuit to the positive busbar. This current would also flow through the fuse in the lamp circuit connecting to *G2*, but as this fuse is cold it would not blow as quickly as the one on *G1* which was already in circuit. I believe that if he will examine the clips of the positive side of the switch on *G2* he will find they are spread apart enough to allow it to close a trifle later than on the negative side.

S. KIRLIN.

New York, N. Y.

Gas Power Department

Elementary Lectures on the Gas Producer*

By Cecil P. Poole

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

A gas producer, of course, is an apparatus for making gas, and any apparatus that makes gas is, equally of course, a gas producer. On this principle an ordinary coal stove is a gas producer because gas is distilled from the fuel burned in the stove; if this were not true, you would have a hard time keeping the fire going. If you doubt this, try to burn a piece of pure carbon. A bottle of muriatic acid with a piece of zinc in it also constitutes a gas producer, because it produces hydrogen gas as long as there is any zinc left in any of the acid. But this series of lectures is limited to producers that make gas for driving gas engines; therefore, methods and apparatus for making illuminating gas and gases that are used otherwise than in engines will not be considered, and all the statements made in the lectures must be understood to refer only to power-gas producers and the gases they produce.

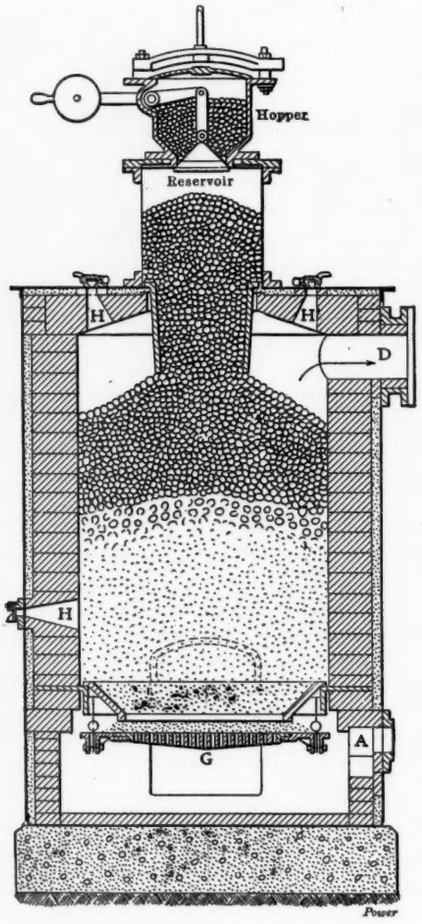


Fig. 1. Simplest Form of Gas Generator

The Generator

A gas-producer equipment consists of at least two principal parts and usually more; two are absolutely necessary, however, and the most important one of the outfit is the "generator." The generator is practically a huge stove, in which the fuel is turned into gases and the refuse, commonly lumped under the name of "ashes," is separated from the combustible parts of the fuel. The generator is a vertical cylinder lined with firebrick and provided with an opening in the top through which the coal or other fuel is deposited, just as coal is fed to the old-fashioned upright drum stove. Some generators have grates to hold the fuel bed, much like the grate of the same old stove from which the generator descended; others have no grate, but some other form of support for the fuel is always provided.

Fig. 1 is a sectional elevation of a typical gas generator and will serve to illustrate the general principle of generator construction. The shell is of steel plate, riveted together just like the shell of a vertical boiler, and lined with firebrick to protect the shell from the heat of the fire. At the bottom is a grate *G* to hold up the fuel bed and below this is the ashpit. At the top is a charging hopper into which the fresh coal is placed for depositing in the generator; this hopper opens into a reservoir bolted to the top of the generator, the opening between the hopper and the reservoir being always closed by a cone-shaped valve except when coal is being dumped into the reservoir. The top of the hopper is closed by a tight-fitting gate to prevent gas from escaping from the generator through the reservoir when the coal in the hopper is dumped into the reservoir by opening the valve.

It will be noticed that the generator has no chimney, the only outlet being that through which the gases are discharged. This is necessary to avoid loss of the gases. The generator is entirely closed, ashpit and all, to prevent air from getting in uncontrolled. Two general methods of maintaining a draft throgh the generator are in use: One consists of forcing the air into the ashpit by means of a blower, in much the same way that air is forced under the grates of a boiler by direct mechanical draft; the other consists of drawing the air through the generator by means of an exhauster at the delivery outlet or else by means of the suction of the piston of the engine taking gas from the producer. Producers supplied with air by the first method are called "pressure" producers and the others are known as "suction" producers. In order to distinguish between producers through which the air is drawn by the suction of the engine piston and those provided with a fan to pull the air through, the former are called straight suction producers, and the latter induced-draft, and sometimes "suction-pressure" producers.

The gases distilled from the coal pass out above the fuel bed through the opening *D*, as indicated by the arrow; this opening is connected by piping to the other parts of the producer equipment, which will be described later. The air for supporting combustion enters the ashpit through the opening *A* and passes up to the fuel bed through the grate, exactly as in the case of an ordinary steam boiler, except that it is first heated and comes to the ashpit through a pipe instead of being admitted through dampers directly from the surrounding atmosphere. With the air is fed some steam, usually; one reason for this is that, if

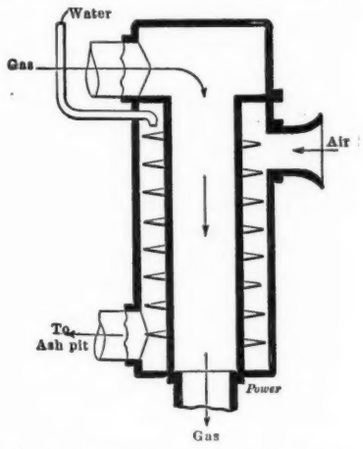


Fig. 2. Combined Economizer and Vaporizer

*This is the first of a series of lectures explaining as simply as possible the "why and how" of power-gas producers. The third lecture will take up the principles of converting solid fuels into gases.

fed with air alone, the fire would become too hot and would fuse the ash and other impurities into hard clinkers that would interfere with the working of the generator.

Around the side of the generator shell and at several points in the top are small holes *H*, through which the conditions in the generator may be observed and the fuel bed poked down from time to time; these are normally closed by covers to prevent air from entering a suction producer or gas from escaping from a pressure producer.

The Economizer and Vaporizer

When the gases leave the generator, their temperature is high, and in order to prevent the waste of the heat which they have absorbed in attaining this high temperature, and also to prevent the gases from being delivered to the engine so hot, upon leaving the generator they are usually passed through an "economizer," where some of their sensible heat is given up to the air that is fed to the ashpit.

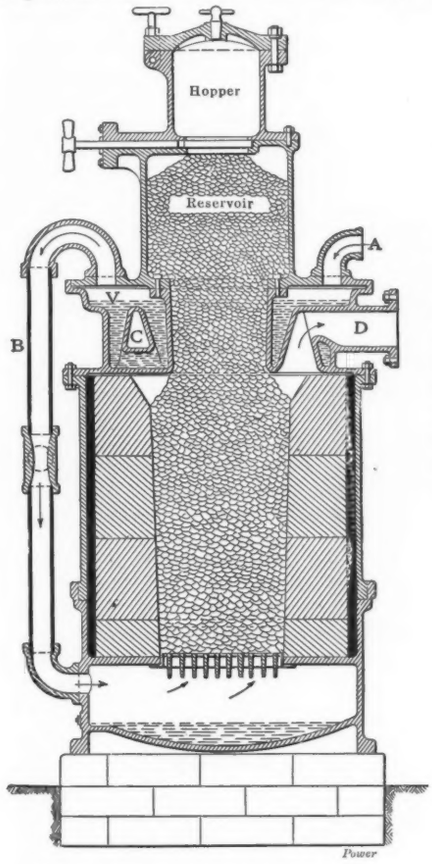


Fig. 3. Vaporizer Built in Top of Generator

In many cases the economizer not only preheats the air with heat from the fresh gases, but also makes the steam that is fed to the ashpit with the air. Then it is a combined economizer and vaporizer. Fig. 2 illustrates the principle of this form of apparatus. Within the main shell is mounted a concentric flue having spiral ribs around the outside. The hot gases from the generator pass down through the central flue; water fed to the spiral ribs is vaporized by the heat from the gases, and air passing down between the flue and the main shell is also heated and picks up the steam from the ribs, carrying it to the ashpit.

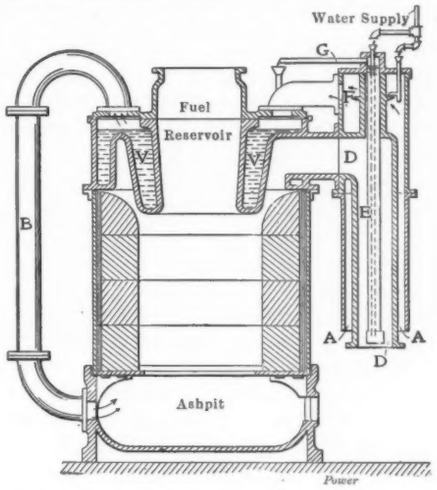


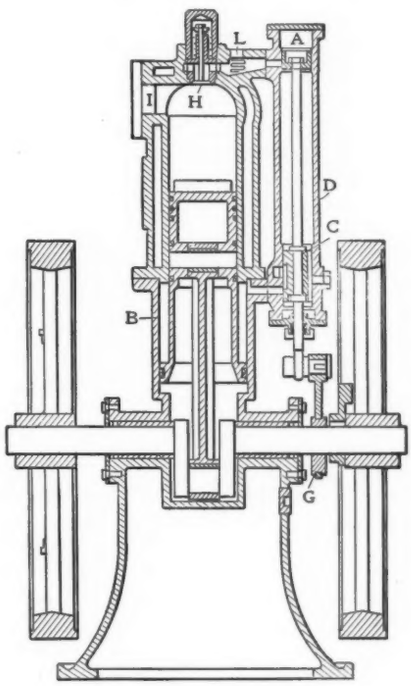
Fig. 4. Built-in Vaporizer and External Economizer

In most suction producers built in Europe, the economizer and vaporizer are built into the top of the generator, as represented in Fig. 3. The hot gases from the fuel bed are supposed to circulate around the annular passage *C* and give up their sensible heat to the water through the walls of this passage; most of the heating, however, is evidently done through the horizontal partition between the fuel chamber and the water chamber. The air enters the vaporizer at *A*, picks up steam from the space above the water and carries it to the ashpit through the pipe *B*.

Fig. 4 illustrates a combination of external air preheater with a vaporizer built in the top of the generator. The fresh gases leave the generator through the pipe *D*, which is surrounded by the air intake pipe and therefore delivers heat to the air, which enters at *A A* and passes upward to the top of the vaporizer *V*, through which it passes to the transfer pipe *B*, leading to the ashpit. Part of the water supply is delivered to a small flange *F* in the upper part of the air pipe and flashed into steam there; this is picked up by the incoming air. The main water supply is delivered to the standpipe *E*, which is stopped off at the lower end; the water is heated by the hot gases passing out of the pipe *D* so that when it overflows through the small pipe *G* into the vaporizer it does not absorb so much heat from the body of water already in the vaporizer as it would if delivered directly to the vaporizer as in Fig. 3. Whether this refinement is of any real advantage in practice or not, I do not know, and this point is not of importance in the present discussion, which is intended merely to describe typical constructions and explain the principles on which they are based.

A New Type of Engine

Many attempts have been made to produce an engine operated on the two-stroke cycle without compressing in the crank case or using an external pump. The result of the latest effort in this direction is illustrated by the accompanying engravings, of which Fig. 1 shows a verti-



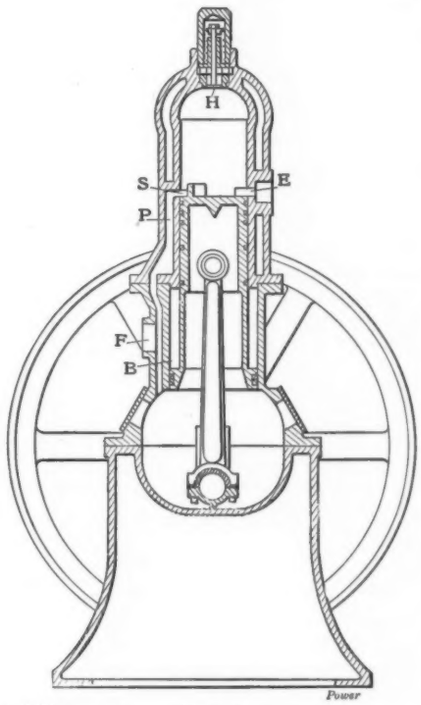


Fig. 1. The "Newcycle" Engine Fig. 2.

cal section on the crank-shaft plane and Fig. 2 another one at right angles to the first; both show the piston at the bottom end of its travel. Upon the upstroke, air is drawn into the crank case and, in the case of a gas engine, a mixture of gas and air is compressed in the annular space *B*, between the piston and an enlarged extension of the cylinder, and the receiver *D* (Fig. 1), the air for this mixture having been previously admitted from the atmosphere by the valve *C*. This valve now delivers the compressed mixture to the receiver *D*. As the piston covers the ports *S* and *E*, the valve *F* opens, allowing the compressed mixture to expand from the receiver *D* into the cylinder through the check valve *H* until the compression produced by the rising piston balances the receiver pressure and allows the valve *H* to be closed by its spring. The mixture in the cylinder is still further compressed and at the end of the upstroke it is fired, as usual, and the expansion of the gases drives the piston down.

During the downstroke, the piston draws fresh mixture into the pump chamber *B* and compresses the air in the crank case. Near the end of the stroke the exhaust port *E* is uncovered by the piston, and an instant later the scavenging port *S* is uncovered, allowing pure air to rush in through the transfer passage *P* from the crank case and drive out the remaining burned gases. This completes the cycle and leaves the cylinder filled with air, ready to take in a fresh charge when the valve *A* opens, after the ports *E* and *S* have been covered on the upstroke.

In the case of an engine using liquid fuel, the pump chamber *B* handles air only and the fuel is injected into the admission passage at *L* to be picked up by the compressed air when it passes from the receiver *D* to the cylinder. The opening *I* is for an igniter plug, and the port *F* in the crank case is provided with a check valve. The slide valves *A* and *C* are operated by an ordinary eccentric *G*.

The engine has been named the "Newcycle." It is the design of Clarence A. Dawley, and it is being exploited by the Newcycle Motor Company, New York.

CORRESPONDENCE

The Gas Engine and the Electric Motor

The remarks of Mr. Beattie in the May 10 number of POWER, under the heading "Small Gas Engines for Intermittent Service," certainly deserve criticism and correction. Of course no one doubts that steam service is both expensive and troublesome, but when he says that the gas engine for small power work is superior to the electric motor he is evidently making an assertion based on prejudice rather than good judgment backed by merit. He first states that in one case a 10-horsepower gasolene engine ran on 90 cents per day for fuel. The average central station can supply current for power purposes for 10 cents per kilowatt-hour, which would give twelve horsepower for ten hours for 90 cents. That doesn't sound like double the cost of gasolene, as he says farther on; and when the rate is cheaper, as is frequently the case, the cost of electricity is far lower than that of gasolene.

Next he says that a good gas engine has been shown to be just as reliable as an electric motor. Anyone with the least bit of knowledge of the facts knows better than that, for the gasolene engine has established a reputation for unreliability, whereas the motor has established its reputation for being always and everlastingly on the job. There is no disputing the fact that a good motor is far in advance of a gas engine, if suited for the load it carries.

Next he cites a case in which a 20-horsepower motor was replaced with a gas engine, thereby reducing the cost to one-half of the cost of electric drive. This may mean almost anything. If his engine was in the natural-gas region, with cheap gas, it would not be surprising if the gas was cheaper; or if the meter measuring the electricity was inaccurate, the same result might be obtained; again, if the rate was based on the lighting rates, or was not set by someone who has had experience with motor business, the cost might have been excessive. But Mr. Beattie's next statement inclines me to the belief that perhaps the motor was an antiquated affair and was not properly suited to its load, for he says that the maintenance of the motor was considerably more than that of the engine.

As a case in mind, I remember that we replaced a 10-horsepower gasolene engine with a 7½-horsepower motor in a machine shop not many years ago. The gasolene engine was in fine shape, but the owner claimed it was overloaded. Often when a rush job was on, the demand would become greater than the engine could supply and, due to the lack of overload capacity which all gas engines seem to have, the works would come to a standstill till they could reduce the load. On the other hand, we put in the 7½-horsepower motor, selecting a good make, and the shop has all the power it needs now, and never has to run any machine below its most efficient speed. The rate there is by a sliding scale, starting with 12 cents per kilowatt-hour and ranging as low as 5 cents. The shop usually gets the 7-cent rate for the amount of power used and the bill has never been more than $16 per month since that motor was installed, whereas before that it used to be about $18 on the average, and sometimes as high as $25.

R. L. PATON.

Franklin, La.

[Both Mr. Beattie and Mr. Paton are right in several essentials of the argument. Mr. Paton apparently overlooks the limitation set by Mr. Beattie in specifying *intermittent* service, but Mr. Beattie's observation as to relative repair bills is directly opposite to almost universal experience. An electric motor of good design will show much lower maintenance expense than a corresponding gas or gasolene engine under equal service conditions. On the other hand, electric power is more expensive than gas or gasolene, as a rule. Mr. Paton's arithmetic is a little out; at 10 cents per kilowatt-hour 90 cents will buy 12 electric horsepower-hours, or about 10½ brake horsepower-hours, which means 10½ horsepower *one hour*, not all day.

The monthly bill for Mr. Paton's 7½-horsepower motor seems to involve an error somewhere. At 7 cents, $16 will pay for 229 kilowatt-hours, or 307 electrical horsepower-hours. If the efficiency of the motor averaged about 85 per cent., the monthly output of work was 260 brake horsepower-hours, which figures not quite 60 horsepower-hours per week. If the shop ran only 40 hours per week, the average output of the motor was only 1½ horsepower, which gives a pretty low load factor. And this is based on the maximum bill, not the average.—EDITOR.]

National Gas and Gasolene Engine Trades Association

The regular semi-annual meeting of this association took place at the Sinton hotel, Cincinnati, June 14 to 16. The number in attendance was notably larger than at any of the previous meetings, and the program, from the preliminary exercises to the end of the meeting, was varied and interesting. Abstracts of those of the papers presented which are of interest to readers of POWER will be printed in an early issue. The titles are as follows:

Graphite Lubrication, by E. G. Acheson.

Ignition in Gas and Gasoline Engines, by Carl Pfaustiehl.

Gas Producers, by L. F. Burger.

Large Gas Engines, by J. D. Lyon.

Utilizing Waste Heat of Gas Engine Plants, by Prof. John T. Faig.

Entertainment features were plentiful and skilfully arranged. The prinicpal event was a banquet at Coney Island, above Cincinnati, in going to which the participants enjoyed a delightful trip on the Ohio river.

A band concert at the Zoological Gardens was another enjoyable feature.

Thursday afternoon was devoted to visiting various manufacturing establishments in Cincinnati.

Racine was chosen as the place of next meeting, which will be held in December.

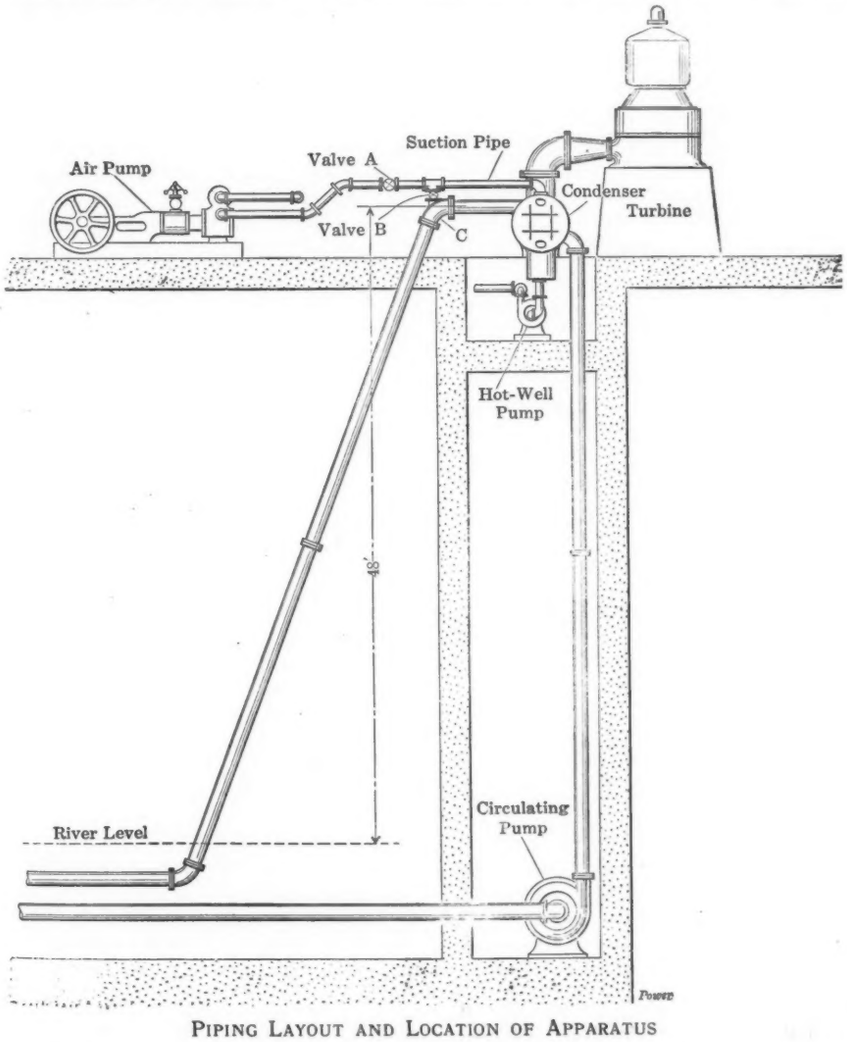
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Operating a Surface Condenser without a Vacuum Pump

In a certain turbine plant using surface condensers, a rather ingenious method was employed to dispense with the use of the dry-vacuum pump. The accompanying sketch, which is almost self-explanatory, shows how this was done.

When operating the turbine, the valve *A* is closed and *B* is opened. The circulating water in falling through the discharge pipe to the river, tends to create a vacuum at the bend *C* as is always the case when siphoning water from a higher to a lower level. The air consequently is drawn into this discharge pipe and passes out with the water. This air entering the circulating-water pipe reduces the siphoning effect that would otherwise exist. The circulating pump therefore does more work than if the air pump were running.



PIPING LAYOUT AND LOCATION OF APPARATUS

When the air pump for any reason is out of commission, the results obtained in the manner described are of utmost value.

The vertical distance from the highest point of the circulating pipe to the river level is in this case 48 feet. Neglecting friction, a perfect vacuum would raise water 33.9 feet. It is therefore easily seen that this method is applicable to any station, with similar condensing equipment, where this vertical distance is over 34 feet.

G. J. REYNOLDS.

Anniston, Ala.

Moving and Raising a Steam Boiler

It was a return-tubular boiler, 72 inches in diameter by 16 feet in length, and was at the railroad station about one mile from the boiler room. The tools and material employed to transport it consisted of two screw jacks, a sledge hammer, 40 feet of 1-inch rope, a couple of lengths of 1-inch pipe 4 feet long, a number of wooden blocks and planks, and several round pieces of straight cordwood which were used as rollers. We first constructed a

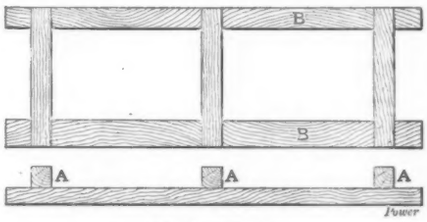


FIG. 1. SKID

skid as shown in Fig. 1, the cross pieces *A* being 6x6 inches and *B* of 3-inch planks. The boiler was rolled upon the skid and wedges were placed at the sides to prevent it from rolling off. We then wedged up the skid until we could place two rollers under it, one at about the center and the other near the front. Next, with the help of some scantlings, used as levers, we rolled the boiler along several feet and by removing the rear roller and placing it under the front of the skid we were enabled to repeat the operation and finally land the boiler at the head of the stairway leading to the boiler room.

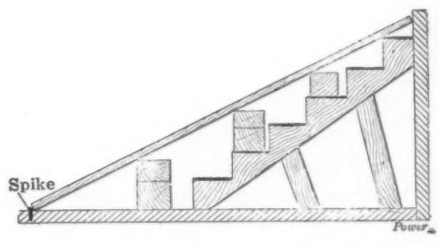


FIG. 2. RUNWAY OVER STAIRS

A runway was constructed over the stairs, as shown in Fig. 2, and the boiler slid down the incline, ropes being used to let it down slowly.

When the right location had been reached, we wedged up the skid until

the jacks could be gotten under one end, and then by blocking it, raised the other end, repeating this operation step by step until the boiler was at the required hight. We then took the lengths of 1-inch pipe and inserted them into the tubes, Fig. 3, allowing several inches to

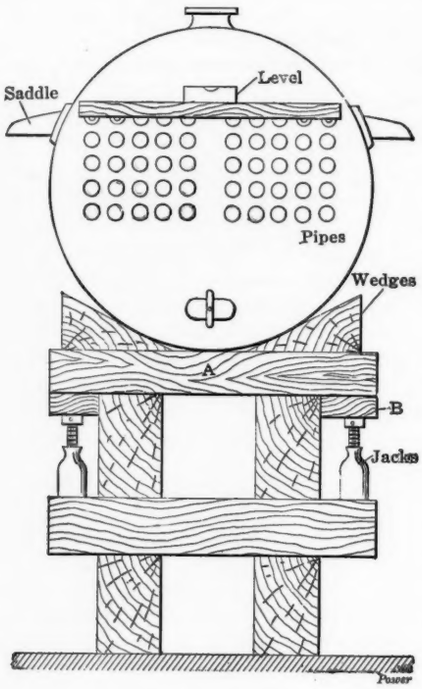


FIG. 3. PLACING BOILER IN POSITION

project from the tubes. Upon these ends was placed a piece of straight wood and a level run along its upper edge. By raising or lowering the jacks the boiler was soon leveled. However, in the longitudinal plane it was set about 1 inch lower at the back end.

J. E. NOBLE.

Toronto, Canada.

Trouble with a Corliss Valve

The crank-end exhaust valve on the low-pressure side of our Corliss engine recently developed a peculiar knock, and

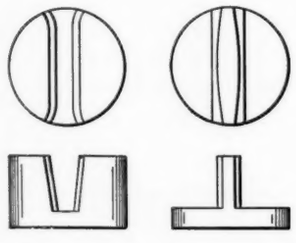


FIG. 1

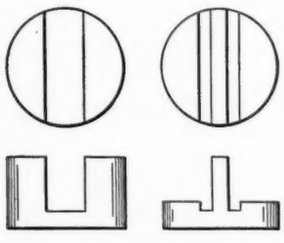


FIG. 2

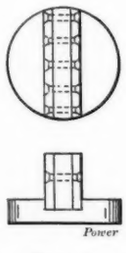


FIG. 3

at each knock the stem protruded outward. I loosened the set screw in the collar, slid the collar back, marked the shaft with a chisel, then replaced the collar and tightened the set screw. This held for a few days, but the vibration finally caused the spindle to jump endwise a full ¼ inch.

Removing the bracket and spindle I found the T-end of the spindle, also the slot in the end of the valve, to be badly worn; so much so that they tended to pass one another at every motion of the wristplate. The conditions of the slot and T-end, when taken out, are shown in Fig. 1. It was quite a problem to repair the T-end without cutting away so much of the metal as would weaken it and cause it to break later. Putting both pieces in the planer, they were trued up and a slot 1/16 inch deep by 3/32 inch wide was cut along each side of the base of the T-end, as shown in Fig. 2. Two pieces of iron were fitted in these slots and riveted onto the sides of the T, as shown in Fig. 3, the pieces being thick enough to make up for the metal planed off the T as well as that cut out of the slotted end. This job could have been accomplished with a file and hack saw, but as we had a planer in the shop it was much easier to use it.

There was considerable end play to this valve and a thin steel washer was placed on the spindle between the T-end and the bracket flange, to hold the former in the valve slot. If the T-end had worn enough to break or slip by the end of the valve, I might have had a wrecked engine on my hands.

R. A. CULTRA.

Boston, Mass.

Repairing a Pulley

One night last summer, the writer, who was then managing a lighting plant in Oklahoma, was called to the plant by the engineer on duty, who complained that he could not keep the main driving belt from running over to one side of the generator pulley. It was found that if the generator was twisted slightly on its foundation the belt would run to the other side of the pulley, and repeated attempts failed to find a position of the machine at which the belt would stay on the center of the pulley.

A straight-edge at once revealed the fact that the pulley, which was of paper, had become so worn that it was hollow in the center. As it was a 90-kilowatt machine it would have been quite a task to remove the pulley and take it to a machine shop to have the surface trued. The writer accordingly procured some heavy wrapping paper and some glue and proceeded to repair the pulley. Strips of the paper of varying widths were cut and glued to the pulley by coating the side of the paper next to the pulley with glue and feeding the strips between the belt and pulley while the armature was slowly rotated in its working direction. Different width strips were used so that a uniform crown might be built up, and the pressure of the belt served to press the paper smoothly onto the pulley. Six thicknesses of paper were found sufficient to put a crown on the pulley which effectually prevented any further trouble.

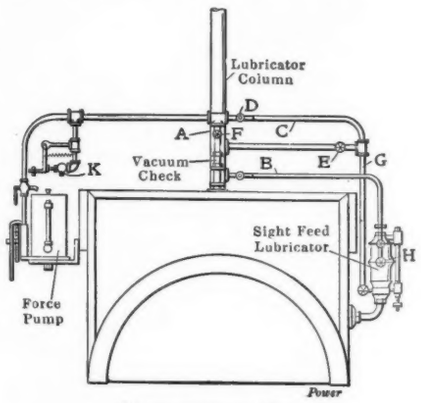
The writer believes that shellac would have been better than glue and that any pulley may thus be crowned whether of iron, wood or paper. In fact, the driving power of an iron pulley would be improved by such treatment.

G. E. MILES.

Denver, Colo.

A Combination System of Lubrication

Most engineers, when given the choice, prefer a force-feed pump to a sight-feed lubricator. At one plant, however, where force-feed pumps were introduced, it was discovered that the quantity of oil fed to the cylinders depended very much upon the temperature of the engine room. The opening of a window would sometimes cause the pumps to feed so slow as to start the engine valves groaning. Of course this was no fault of the



COMBINATION FEED

pumps, for undoubtedly lubricators under the same circumstances also would have fed slowly. But with the latter, the fact would soon be discovered by the oiler, for each drop is visible, whereas the three-way cocks on the force-feed pumps are seldom tried oftener than once an hour. A combination of the two, then, would seem to be an ideal method of feeding.

The system shown in the illustration has been rigged up for trial only; good valves will replace the cocks and the

scrap relieve valve, if the method proves successful, as it now promises. It will be noticed that either the pump or the lubricator may be used separately, the feed from the pump flowing through the pipe *A*, and the feed from the lubricator flowing through pipe *B* into the cylinder. Pipe *C* interlinks the pump and the lubricator, and its use, if cock *D* be opened. and cock *F* and valve *E* be closed, results in directing the flow of oil from the pump through the condensed-water pipe *G* and into the lubricator; from which, if the system is previously filled, it will escape through the sight feeds just as fast as it is sent over, provided the regulating valves *H* are opened sufficiently. At present the pump is made to feed slightly faster than the opening of the sight-feed valves on the lubricator will permit the oil to escape, the excess being forced out under the weighted disk of the needle valve *K*, which acts as a relief valve.

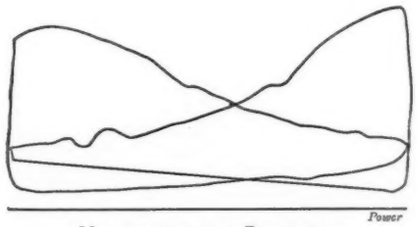
Since this system was adopted, there has been no occasion to reset the crosshead plunger screws of the pump, for all regulation of feed is done with the sight-feed valves of the lubricator. The relief valve *K* must not be overweighted, but should open freely with the rise of a few pounds excess pressure within the oil pipes.

K. P. EVERETTE.

Boston, Mass.

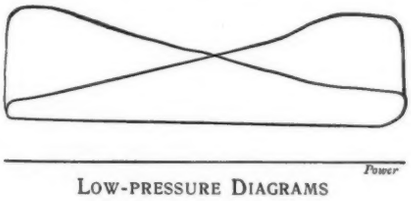
Diagrams from Piston-Valve Engine

I would be glad to have POWER readers criticize the accompanying diagrams taken from a high-speed, piston-valve,



HIGH-PRESSURE DIAGRAMS

compound engine. The high- and low-pressure cylinders are 12-11/16 and 20 inches in diameter respectively. The



LOW-PRESSURE DIAGRAMS

stroke is 12 inches. The steam pressure at the boilers was 110 pounds at the time the diagrams were taken and the speed of the engine was 275 revolutions per minute.

LOUIS FREDERICKS.

New York City.

Unusual Diagrams

I purchased a steam-engine indicator recently and applied it to some old elevator engines which I have in charge. The diagrams are so out of the ordinary that I am no wiser now than I was before they were taken. Perhaps some readers of POWER can tell me what is wrong with the engines. What I wish particularly to know is, would it be safe to cut off the steam pressure?

The engines were built in 1863 and in so far as I can learn, they have never been altered since leaving the shops. Each engine has two cylinders, the valves of which are operated by the same eccentric. The engine is reversed by a pilot valve, the arrangement of which is shown in Fig. 1. Steam is admitted through port *A*. Port *E* is the exhaust to the atmosphere. When the elevator is going up, port *B* of the cover coincides with *B'* of the valve and the steam enters the steam chests through the passages as shown. The part *C* of the valve cover forms a communication between *D* and exhaust port *E*, which allows steam to escape from the cylinders through the valve chests and passages *F*.

When it is desired to start the elevator car down, the reverse lever throws the cover to the left a quarter of a turn. This brings part *C* over *B'* and exhaust *E* and steam from the ends of the steam chests is allowed to pass out. The small holes *Q* are opposite port *D* and steam passes through passages *F* to the steam chests and causes the engine to reverse. These holes are just large enough to supply sufficient steam to start the car from a standing position; once the car is in motion, gravity brings it down.

The diameter of the cylinders is 8 inches, and the length of the stroke is the same. The boiler pressure is about 80 pounds. The engines, at full speed, operate at about 180 revolutions per minute.

In Fig. 2 are shown two typical diagrams.

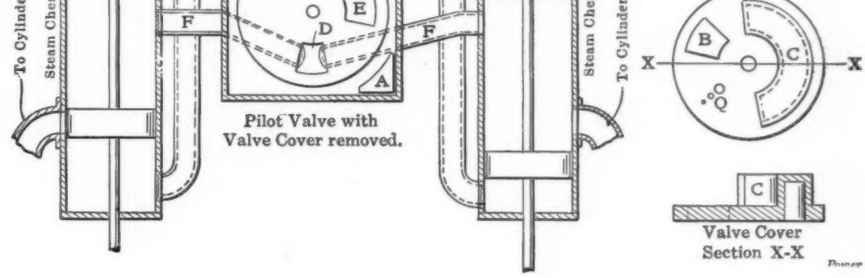


FIG. 1. VALVE AND COVER

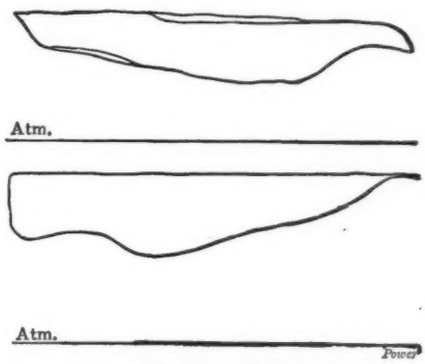


FIG. 2. TYPICAL DIAGRAMS

W. S. ROYAL.

New York City.

Unnecessary Heat Waste

About fifteen years ago I was employed by a small electric-light company as combination arc-lamp trimmer and fireman. I trimmed the arc lamps in the middle of the day and the afternoon and fired the boiler from 6 o'clock to midnight. We had a 100-horsepower return-tubular boiler and a 125-horsepower Payne automatic cutoff engine. There was also a water wheel to help out.

Water was delivered to the boiler by an injector; we did have a pump but it was never used. There was no feed-water heater. Later the company put in a larger engine and condenser and two 150-horsepower boilers. In neither of the plants were the steam pipes covered, and no attempt was made to heat the feed water. I asked the engineer of the other plant why he did not cover the steam pipes. He said it was so hot up there that covering would do no good! It is strange that engineers and owners of small steam plants do not wake up to the fact that with a small outlay in money they could at least install a feed-water heater, and save the coal required to heat the feed water, which is pumped cold directly from well or city mains. There are many small lighting and power plants, especially in the northern

part of the State, where coal is high in price, in which no attempt is made to heat the feed water or to cover the steam pipes.

H. B. BRAND.

Brooklyn, N. Y.

Faulty Reducing Motions

Many different methods of reducing the stroke of an engine preparatory to taking a diagram, are a source of deception to the engineer, much faulty valve setting being due to the fact that he takes

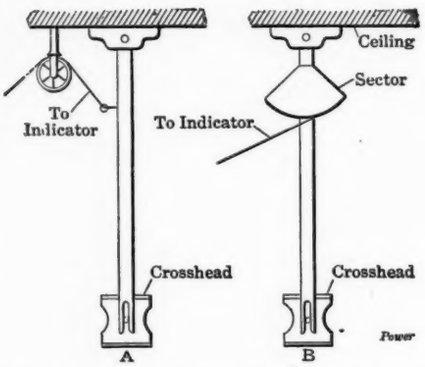


FIG. 1. IMPROPER AND PROPER WAY TO ATTACH CORD

for granted that the reducing motion is correctly rigged.

As an illustration, I once had an engine to indicate, and previous parties had attached a rig as shown at *A*, Fig. 1, which although simplicity itself, is far from being correct. The diagram from this is shown in Fig. 2; it being not only un-

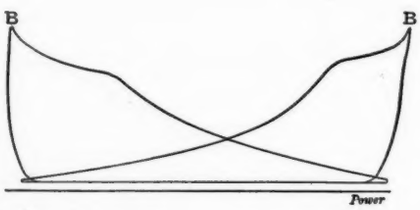


FIG. 2. DIAGRAM TAKEN WITH CORD IMPROPERLY ATTACHED

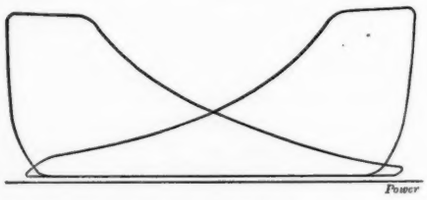


FIG. 3. DIAGRAM TAKEN AFTER SECTOR WAS USED

equal in cutoff, but indicating that the eccentric was too far ahead, thus giving the excessive lead and causing the points at *B B*. If I had made corrections at the valve gear because of these apparent defects, I would have only made matters worse. But instead, I attached a sector, as shown at *B*, Fig. 1, and without changing the eccentric or valve gear, I obtained the card shown in Fig. 3, which emphasizes how one can be misguided by an incorrect reducing motion.

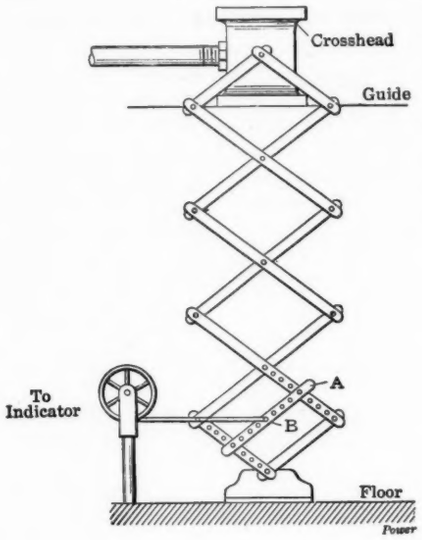


FIG. 4. PANTOGRAPH

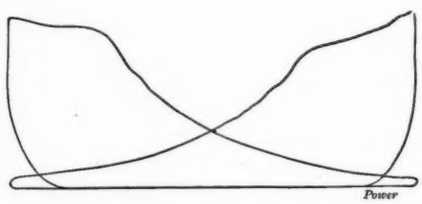
Another case is in the use of the pantograph. I once saw the length of diagram shortened by lowering the crossbar *A*, Fig. 4, without changing the pin *B*, and the valves were manipulated to conform to this erroneous indication. After moving the string pin one hole nearer the floor standard for every hole that the crossbar was lowered the resulting diagram was entirely different and the valves had to be changed over again to conform to the correct motion.

A. C. WALDRON.

Lynn, Mass.

Diagrams for Criticism

The following diagrams were taken from a Filer & Stowell engine, running under a boiler pressure of 130 pounds and exhausting into the dryers of a paper-making machine, the back pressure ranging from 6 to 14 pounds.



DIAGRAMS FROM HIGH-PRESSURE CYLINDER

Will some readers of POWER kindly criticize the diagrams and inform me where I can make improvements in the adjustment of the engine.

SAMUEL MOBERG.

Merrill, Wis.

Unexplained Breakage of Follower Bolts

Last fall our 18x24-inch automatic high-speed engine broke one of its follower-head bolts, but no damage was done. We overhauled it this spring and after running only two days another broke, but this also caused no damage. I put in a new set of bolts and the engine ran only about a week when another broke without warning, this time breaking the piston and the cylinder head.

The piston always sounded as though it were loose, but upon inspection I found everything to be secure. We now have a new piston installed and that has a pound in the rear end sounding as if it were striking.

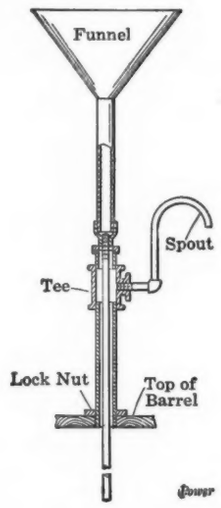
Can anyone explain the cause of these breaks?

JOSEPH HANDLEY.

Gladstone, Mich.

A Homemade Hydraulic Oil Pump

The sketch shows a homemade oil pump which I have used for some time with very satisfactory results.



OIL PUMP

The pump is inserted into the head of a barrel and water poured in through the funnel at the top, thus passing down through the inner pipe and into the bottom of the barrel. The water being heavier than the oil displaces the latter, and causes it to rise in the outer tube and flow out at the curved spout.

This arrangement keeps the barrel clean and the water prevents it from becoming dry.

By making the funnel of one gallon capacity, a gallon can may be used to catch the oil without any danger of overflowing.

B. N. EVERETT.

Jamestown, N. Y.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Steam Liberating Surface

The accompanying curves were plotted from 18 tests conducted by the United States Geological Survey at St. Louis in 1904. There were two 210-horsepower Heine boilers; each had a steam drum 42 inches by 21 feet, 6 inches long, which contained 2031 square feet of heating surface, 73 cubic feet of steam space, and 287 cubic feet of water space. The 6-inch steam nozzle was at the front end of the drum and was provided with the usual deflection plate and dry pipe. A Schaeffer & Budenberg separating calorimeter was used in most of the tests. A tee was located immediately above the nozzle and to the pipe entering this tee the calorimeter was connected.

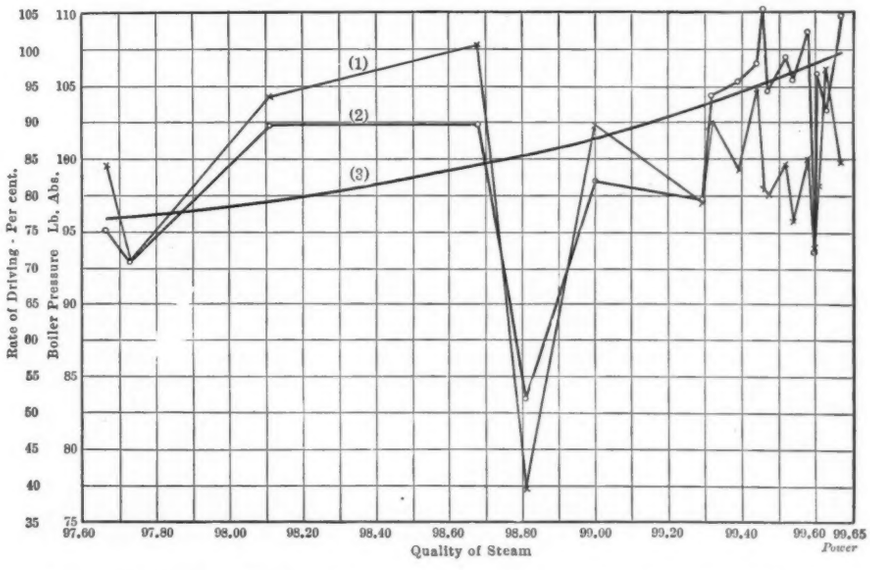
The boilers were set inclined to the rear, 1 inch in 12. Considering the boiler to be horizontal and the drum half full of water, the total steam-liberating surface is approximately 76 square feet. It is generally conceded that the circulation of water is down the rear header and up the front one. Granting this, it is very evident that the effervescence of steam is of greater violence in the front than in the rear of the drum. Therefore, every square foot of liberating surface is not equally useful in performing its function; that portion above the front header works "overtime" while that above the rear header is comparatively quiescent. It would seem then that drier steam could be had by placing the nozzle near the rear of the drum. Referring to the curves, No. 1 shows the relation between boiler pressure and quality; No. 2, the relation between rate of driving and quality; No. 3, the relation between approximate average rate of driving and quality of No. 2.

Curve 3 shows that the quality increases with the rate of driving. There are no very great overloads in the tests, so how far this deduction applies cannot be determined from the data at hand. A curve similar to No. 3 but referring to No. 1, i.e., to boiler pressure, would be practically horizontal. This would tend to show that the quality was independent of the boiler pressure. Since the volume varies inversely as the pressure, these actual results are in direct opposition to theoretical deductions.

The quality is probably influenced to a great extent by the character of the water and by the efficiency of the method of baffling.

GEORGE C. OLMSTED.

Crystal Falls, Mich.



CURVES SHOWING RELATION BETWEEN PRESSURE AND QUALITY AND RATE OF DRIVING AND QUALITY

Indicator Cord Hook

In the April 26 issue there is an article on the above subject by John Bailey in which he shows sketches of a "common" and an "improved" cord hook. After having tried a great many forms of hook, it is my belief that Mr. Bailey would get much better results if he turned his attention to devising a hook that could be attached at the "in" end of the stroke instead of at the "out."

As Mr. Bailey states, a very strenuous time can certainly be had with the indicator cord when you miss fire in trying to connect, with the cord pulled out the length of the stroke, as is necessary with the "improved" hook. By hooking on at the in end of the stroke, there is no damage done if you do not connect; you simply try again. It does a reducing wheel no good to take in two or three feet of cord with a bang and sudden shock which is almost sure to happen if you let go a shade late or early in trying to hook on at the out end of the stroke; that is, unless the crosshead attachment gathers in the flying cord and tests its tensile strength.

With equal practice a beginner will learn to hook on at the in end of the stroke just as easily as at the out if he uses a little horse-sense in shaping the hook. In addition, there is no risk of wrecking the reducing wheel in the event of the cord being extra strong.

For years I have been on the lookout for a cord-coupling device on the market, and never having seen one advertised, I came to the conclusion that there were none for sale.

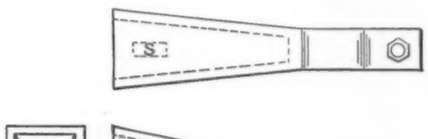
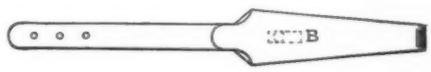


FIG. 1



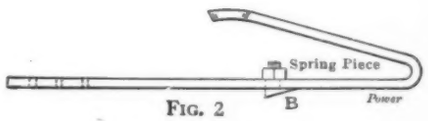


FIG. 2

INDICATOR-CORD COUPLER

The accompanying figures represent one that I am making after having tried some experiments as to piston speed, vibration, etc. The coupler consists of two pieces, the socket, Fig. 1, for clamping to the crosshead attachment on the engine, and the V-shaped spring, Fig. 2, to the end of which the indicator cord is secured. The socket piece has a small oblong hole in the bottom shown at *S* in Fig. 1, into which the bottom of the wedge bolt *B* of Fig. 2 fits when coupled together. The slight compression of the spring piece will serve to hold the two members of the coupler rigidly together. The figures show plainly the tapered shape of the two parts for the purpose of making the entrance of the one into the other easy at high speeds.

To make a connection the latch spring is held in line with the socket piece, which has been clamped onto the crosshead. The spring is moved forward until the socket rides onto it far enough to engage the wedge bolt. To uncouple, the hand is slid along the string until it touches the spring. A quick upward pull at the in stroke will then disengage the coupler.

J. A. CARRUTHERS.

Bankhead, Alberta, Canada.

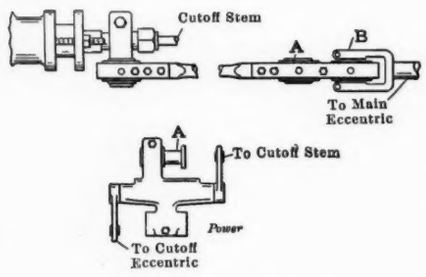
Wedge Bolt Troubles

Referring to my letter, "Wedge Bolt Troubles," printed in the April 26 issue of POWER, the accompanying figure will show how such a connecting-rod end is used.

It is readily seen how brass *B* is connected to the main eccentric rod, thus giving travel to the main valve.

The front brass or *A* is connected to pin *A*, giving motion to the rocker.

The cutoff valve is worked from the same rocker by means of a rocker shaft and arms.



CONNECTING ROD END

I think the sketch will show very clearly how the rod is used. I may add that it is used on a Buckeye engine, the speed of which is 257 revolutions per minute.

FRANK W. BELLINGER.

Havre, Mont.

Theory and Practice

The letter by Mr. French on the above subject in the issue of May 31, touches me on a tender spot. I believe that it is true that technical graduates suffer needlessly during their first years in the open and that as a result the community at large suffers.

It is a common statement that a graduate must lose 75 to 100 per cent. of what he has learned before he is worth anything. If this is true, then there is something wrong with the college faculty that persists in offering a curriculum of which three-fourths or all is worthless. I, for one, do not think that it is true, though I did believe it five years after I received my sheepskin at one of these schools. The trouble is this:

Boys graduate from college at 21 or 22 years of age, crammed full of useful knowledge and youthful spirits. The knowledge has a positive value, the youthful spirits have a negative value. The youthful spirits have to wear off before the knowledge will be given a show. This takes, on an average, three years after leaving school. A post-graduate course does not decrease the length of the three years by more than a week. Can one wonder if the boy whose chief pleasure has been that of chasing his nose around a four-lap track or another whose principal aim in life has been to carry a certain egg-shaped object where someone else did not want it takes time to develop into an engineer concerned with questions of profit and loss? Is it strange that a young man whose method of raising money has been to write home to "Dad" finds it difficult to realize how much mental concentration it takes to make a dollar?

As a matter of fact, during the three years or so that our average young man spends in gradually sinking to his level he may likely forget a lot of things that are not pertinent to what he is immediately concerned with.

Every technical school in the country is studying this problem, which may be stated as the problem of getting boys to take upon themselves responsibility and to work actually rather than to play at working. Just as long as a boy in the senior class of a college can take a partially completed problem up to a teacher and ask if it is right so far, and as long as he can leave problems at home on the piano and be allowed to bring them in next day, he cannot be expected to go out in the world and stand without crutches. How to put a young man on his own responsibility is an easy task for an employer. He simply puts him onto a job and if he does not make good, discharges him. The schools reject so large a proportion of those whom they admit that it would seem radical to suggest any more drastic measures. At the same time, it seems to me that a more strict policy in this respect would produce amongst the student body a more keen appreciation of what they are in school for and in the end increase the percentage of graduates.

Another difficulty lies in the gradual transition from preparatory to technical schools, with the consequent adherence to the traditions of the preparatory schools. If the upper classes could be isolated from the lower and given entirely separate instructors, hours and environment, it might be possible to pass this disagreeable three years in school and graduate a young man ready to step into his place in the world without the necessity of forgetting that knowledge for which his employer most needs him.

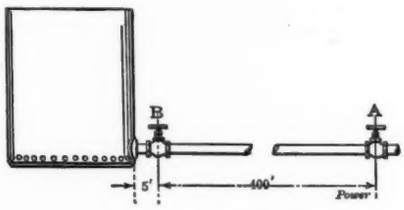
E. F. HENRY.

Worcester, Mass.

Never Open or Close a Stop Valve Suddenly

All rules have their exceptions. There is that old, reliable rule which we have heard so often: "Never open or close a stop valve suddenly." One brother reports that he once was reprimanded by an old engineer for putting this rule into practice in connection with a blowoff valve.

It used to be a mystery to me how mechanical engineers could have the nerve to write in big, bold letters: "Never open or close a stop valve suddenly," and then install, for a boiler blowoff, a cock which requires only a quarter turn to close it, and which usually fits so tight that when sufficient pressure is applied to move it at all, it will close completely. And yet I have never seen a blowoff cock give way under the action of waterhammer.



LOCATION OF VALVES

To produce waterhammer two things are essential, weight and motion. In a water pipe the weight of water depends upon the length of the pipe. The figure represents a line of pipe carrying water at a rate of 200 feet per minute. Suppose that the valve *A* were suddenly closed, it is obvious that it would be subjected to a tremendous blow. But such would not be the case in closing the valve *B* for the reason that instead of 405 feet of water, we have only 5 feet now to deliver the blow.

This is similar to the boiler blowoff which is located in close proximity to the

boiler. Why not, then, close this valve quickly to prevent scale from being caught on its seat and keeping it from seating properly?

Suppose we keep in mind our iron-clad rule: "Never open or close a stop valve suddenly," but modify it slightly by the following: "Always close a blow-off valve quickly."

J. M. Row.

Fort Monroe, Va.

Colors for Station Piping

I read with considerable interest the recent articles in POWER on painting pipes in different colors to distinguish them. I have had in use for the past two years in factory work a system of colors for pipes and as I had no precedent to go by I adopted the following method:

All high-pressure pipes were of a solid color, including fittings; the returns from these pipes were painted the same color, but the fittings were given a color decidedly sharp in contrast.

In industrial work many additions are needed to those for regular power-house piping; therefore, it was necessary to have a considerable number of easily distinguished colors.

Bright colors in waterproof paint were selected; a partial list is given below.

As steam pipes were covered with asbestos in white, little change was necessary for steam piping.

High-pressure steam pipes and fittings, white. Low-pressure and exhaust-steam mains: pipe, white; fittings, black. High-pressure hydraulic systems: pipe and fittings, yellow. Low-pressure hydraulic system or returns from high-pressure system: pipe, yellow; fittings, bright red. Fire and sprinkler systems; pipe and fittings, bright red. City gas; pipe and fittings, brown. Producer gas: pipe, brown; fittings, white. City water, bright green. Circulating or cooling water returns, dark green. Hot-water and boiler-feed lines, bright blue. Blowoff lines and trap returns: pipe, bright blue; fittings, red. Fuel-oil lines, black. High-pressure air: pipe and fittings, gray. Low-pressure air for spraying oil in fuel-oil burners: pipe, gray; fittings, black. Other colors to suit conditions were added without confusion to this plan, when needed.

I should be glad to have some method of painting pipes adopted as a standard by the American Society of Mechanical Engineers and approved by other societies. This would gradually be adopted as standard practice for all factories and power houses. I am glad that this matter has been brought up and I hope that it will be pushed by all engineers until some satisfactory method is adopted.

W. N. McKEE.

Chicago, Ill.

Blowoff Tank

Referring to "Accident to a Blowoff Tank," in the May 17 issue, it looks as though the blowoff valve had been opened too quickly, and because of the outlet pipe being too small as compared with the inlet pipe, the cover of the tank flew apart. It seems to me that the construction as illustrated would not meet with the approval of any engineer who had given the matter any thought. All of the pipes are of the same size, which does not give the tank a chance to free itself as quickly as it should and otherwise would. The outlet pipe should be considerably larger than the inlet, and so also should the vent pipe be larger than the inlet.

The blowoff valve should never be opened suddenly, for by so doing an accident is possible with a tank of approved design. Although the tank in question was not all that could be desired, yet the accident might not have occurred had the proper proportion been employed in the pipe sizes, and had the cover been strengthened by ribs as in the case of a cylinder cover of an engine.

CHARLES J. MASON.

Scranton, Penn.

Applying Patches to Boilers

The article in POWER for May 24 on "Applying Patches to Boilers," while containing some well known facts often dilated upon, has some statements that may be questioned. The writer states that patches are provided because a certain part has deteriorated to the extent that economy in the generation of steam is impossible. As a matter of fact we patch boilers not for the above reason but for the sake of safety. A patch does not improve the economical operation of a boiler and to some extent may give the opposite result. That return-tube boilers may bag on account of foreign substances preventing transmission of the heat from the plate to the water is as trite as the weather topic. But bulges or bags may now and then be found that are not explainable by the theory of foreign matter, as any boiler inspector of a few years' experience will certify.

Granting, however, a bag on a fire sheet of a horizontal tubular boiler and that someone qualified to pass on same has decided that it must be cut out and a patch put on, we would want more exact information than is given in the article in question. Say it is necessary to cut out a section of the plate for a distance of 20 inches from the girth seam, that 20 inches to be measured on a line parallel to the axis of the shell. Say the longitudinal seams are butt joints of 87 per cent. efficiency and that the patch must have an efficiency of almost this amount and be single riveted. In 90 per cent. of the horizontal tubular boilers the patch will be on the sheet over the fire where the temperatures vary the most and range the highest. Certainly, the workmanship, including the layout, must be of the best, else renewal will be needed in a short time. To lay out and put on properly a patch at this point and have a tight, durable job is the work of a skilled boilermaker but, of course, the engineer should understand the details in order to know a good from a poor job. To begin with, the patch must go inside of the shell to avoid having a pocket for the collection of scale and also in order that the pressure bearing on the patch will be carried by the shell plate and not by the rivets. An outside patch is a mean one to keep tight. Assume the shell plate to be of ⅜-inch steel and the rivet holes to be 13/16 inch in diameter at the girth seam, the pitch of same to be 2⅛ inches, the distance from the center of rivet holes to the edge of plate $1\frac{7}{32}$ inches and the total lap $2\frac{7}{16}$ inches. The patch should be riveted the same way except, perhaps, a trifle more lap at the calking edge of the shell plate. Lay out on the plate a line from center line of rivet holes 20 inches long and center punch the ends of the line, having it parallel to the axis of the shell. From the intersection of this line with the girth-seam line strike a half circle of 20 inches radius. This should bring the patch up out of the bottom in order that the rivets at the end of patch toward the girth seam, which must embrace three thicknesses of plate, will be out of the fire as far as possible and the inner heads will be in a vertical position rather than a horizontal one. These two rivets are the most difficult to keep tight of all on the patch and the higher they are located the better is the durability.

Next, the defective plate must be trimmed out along the lines laid out. Then, the rivets are cut out at the girth seam in the affected section, including a few beyond the patch line. This done, the pitch-line circle is drawn on the plate, it being brought in or out where it touches the girth seam in order to have it in line with the rivet hole at each end. With a compass set for 2⅛ inches the rivet holes are laid out on the plate on this line. In doing this, start from each end and work toward the midlde with a view of having the wide pitch, if any, at that point instead of on one side. Laid out on the above line we will have 16 rivets from the girth seam to the center line of the patch. Now, if this patch were a square one 20 inches long plus the distance to the pitch line, it would take 10 rivets and the efficiency of the joint would be, say, 56 per cent. But, owing to the curve, it requires 16 rivets to this line and it follows that the efficiency equals

$$16 \times 56 \div 10 = 89 \text{ per cent.}$$

Hence, the efficiency of the joint equals

or even exceeds that of the butt joint. We may vary the curve in order to suit local conditions but this is a general and a safe rule in laying out patches.

The plate is now screw-punched for the rivet holes and in doing this it is best to have the punching ⅛ inch below size in order to ream out true. Now make a paper templet of the proposed patch, springing the sheets apart where the triple lap will come to mark off the holes correctly. Go to the shop and roll up a piece of plate and cut to fit the templet. Drill the rivet holes carefully and scarf the end corners down neatly. Place the patch in position, bolt it up well, adjusting to fit, and ream out the rivet holes to a neat fit all around after the patch is well shaped and fitted. When it comes to riveting, it is better to have a good holder on the inside of the boiler than to use a long bar and fish the rivets through the holes. This matter of fishing hot rivets is a last resort and should not be tolerated when a man can get directly at the job. Grant then a holder on the inside. With a supply of ¾-inch bolts on hand bolt up solidly every other hole and rivet up with two good riveters who continue driving until the rivet has "set." The job is finished by chipping and calking. Of course, special attention is given to the rivets through the triple lap at the corners where this lap is liable to give trouble owing to its thickness. The formed rivet heads properly done will be as strong as the mill heads, and, of course, will be steeple shaped.

If it is necessary to patch a sheet away from a circular seam the same general directions will serve. The patch, of course, being semi-circular along the line parallel to the axis of the shell, its efficiency is easily determined by the number of the rivets in the circular end and by the number that would have been used in a straight line, the pitch and rivet holes being the same in each case. In some cases, "diamond" patches are used. An instance will explain. A 72-inch by 18-foot boiler with a 3-inch blowoff pipe attached to a flange on the rear bottom sheet bagged at the rear end, the pipe letting go. The bag was 26 inches long. The affected metal was cut out from the back head to the girth seam, taking in four rivets in the girth seam and 20 in the rear-head seam. A single-riveted patch was put on with a flange on it for the blowoff pipe. The efficiency of the joint was above that of the longitudinal seam.

In regard to fire cracks at girth seam, and repairs to same, in practice no one trims the plate down as shown in Fig. 8 of the article in question, for the reason that it is not practical or possible to do this. The aim is to strengthen not weaken a seam. If fire cracks leak, cut out and ream the holes true. Drive an overlap rivet to cover the crack. With a horizontal tubular boiler, the stress on a circular seam is low. Take a 72-inch shell under 100 pounds pressure. Then,

$$Radius \times pressure = Stress$$

on the shell along a line parallel to the axis. The stress on the circular seams equals one-half of the above value or 1800 pounds. But the tubes take up about two-thirds of this; hence, the stress is about 600 pounds per square inch or one-sixth of that on the longitudinal seam. To keep the cracks from leaking, spring arches, if possible, to protect the seams from contraction. When necessary to patch, use a ribbon-shaped patch at least 9 inches wide. A narrow patch will give more trouble through lack of room to "breathe." Locate this patch well up on the side, as described, with semi-circular or "horse-shoe" patch.

As for using paper as a gasket, in an experience of 40 years, I never met with a patch so poorly laid out that it required paper or red lead on the fire sheet. Patches in the steam dome of a boiler have been put on with copper gaskets (annealed), leaving the edge for calking. Cast-iron fittings riveted on top were often put on with such gaskets, but with forged-steel flanges gaskets are unnecessary.

Another statement in the article may be challenged, namely, "As long as the one side is directly in contact with the water it will never become overheated." I have inspected vertical boilers, Hazleton type, in which were found bulged plates above the grates and below the tubes and these were not chargeable to scale, low water, or foreign matter, but to the generation of steam being so rapid that the water was forced away from the sheet, permitting local overheating with resultant bulging. This is well known among men familiar with this boiler and others of similar design. The remedy is a course of firebrick around the shell up almost to the tubes.

T. T. PARKER.

New York City.

In the issue of May 24, H. S. Jeffery says some things on the subject of boiler patching which merit mild criticism. As a whole, the article is a series of platitudinous statements of self-evident facts, careless misstatements and a mixture of the two.

It would be interesting to have a few questions answered by the author.

How can a patch improve economy in the generation of steam?

Do boilers ever get *full* of mud or scale?

Is not a boiler safe from overheating so long as the scale-forming matter can be kept in the form of mud?

How can the efficiency of the single-riveted joint of any of the patches shown be made equal to that of the double-riveted longitudinal seam as he says is necessary?

"Horseshoe" and "diamond" patches may be designed with a single-riveted seam of 80 per cent. or more efficiency, but there is nothing in the article that hints at the method of doing this.

When a man says anything in the technical press for the purpose of giving instruction or imparting information, his language should be both exact and in accord with current practice. It is hardly necessary to call attention to the fact that this article falls short of these requirements.

THOMAS HUGHES.

Saugus, Mass.

Safety Appliances

C. E. Granfield, in the May 31 number, criticizes H. R. Rockwell's article in a previous issue about safety appliances.

Mr. Rockwell is undoubtedly correct as no safety appliance is of any value unless it has a reasonable amount of care and attention. One should not suppose that merely the word automatic on an article will make it proof against all ills. Some of the old timers kick at the safety water glass and column; this, however, does very little harm to the merits of the column. Safety water columns get scale in them, on the rod, float and connections, and give trouble and the remedy is the same as in the case of the dirty boiler, namely, keep them clean. Sometimes floats will leak and fill with water, but how much time does it take to take the column apart and fix the float; not very much I am sure.

The water glass of which Mr. Granfield speaks may have been broken during the night when there was little steam in the boiler and for this reason probably did not cause enough commotion to make the safety appliance work. Or possibly the valve was full of mud, the result of not being blown out often enough. I have known pet cocks to be on glasses and not used at all, the large valve on the column being relied on to clean the entire column.

Don't kick too soon about that word automatic. Where would our engines be today if it were not for the automatic governor? Even here, at certain times, it takes a liberal amount of work and coal oil to make the governor do its job right.

To those brothers who have trouble with dirty boilers where the mud is soft and likely to cause foaming, I would recommend the use of a skimmer. If the boss won't buy one, they can make it themselves. With a little extra work a good skimmer can be rigged up and it will do away with a lot of extra boiler cleaning.

L. L. SCHEIDNER.

Marysville, O.

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Power and The Engineer

Editorial

An Early Suggestion of the Low Pressure Turbine

In view of the recent development and success of the low-pressure turbine the following suggestion which appeared editorially in POWER for July, 1903, is interesting:

Since the turbine is less efficient than the reciprocating engine in the early stages of expansion, but is capable of carrying the expansion practically to so much greater an extent, the idea suggests itself that the turbine might be used to replace the low-pressure cylinder of a compound engine. This would mitigate the loss from internal condensation, as all the heat which goes into the first cylinder, with the exception of that lost by radiation and converted into work, must pass to the receiver and would be available for use in the turbine through the lower temperature range. Great ratios of expansion would be available and the enormous cylinders necessary for even the limited ratios now attained would be avoided. The simplicity and compactness which are such attractive features of the turbine would be, however, in a measure sacrificed, as would the particularly advantageous use of superheated steam and the avoidance of oil in the condensed exhaust.

Water Hammer in the Early Morning

The attention of readers of POWER has been recently directed to those power-house accidents which are particularly liable to happen at the time when the plant is ready to start up. The interest which has attached to these discussions prompts a further review of the dangers surrounding the changes from the cool night conditions of the steam pipe in a large factory plant to those of heat and pressure when power is called for.

A normal set of conditions will be assumed for illustration, where the shut-down of the evening before took place at six o'clock. The main pipe from the boilers comes from a battery of good size, with curved branches from each boiler taking into well designed fittings on the main line. The latter will be called fourteen inches in diameter, well drained by drip pipes. Each boiler has its own stop valve on its branch. When the engine throttle was closed, the boiler stops were closed shortly thereafter, and the drips opened. The boiler fires were banked, and steam is to be raised to working pressure in the morning with the stops closed so as to minimize the condensation in the piping and the loss of coal and heat through the escape of steam vapor through the drips. The conditions will be recognized by a great many as usual and by no means improper or unsafe. The pressure in the pipe line falls to that of the atmosphere through the open connections of the drips, unless a boiler stop is leaking faster than the steam can get away. The temperature of the metal in the pipes falls with the pressure, since the steam vapor at a low pressure has very great avidity for heat and will abstract it with great rapidity, as in the phenomenon of heat flow to the exhaust and internal condensation in a steam cylinder.

In the morning, the boiler tenders have raised heat and pressure in the boilers, and from some one of them the stop valve is to be opened to warm up the pipe, fill it with hot dry steam and later establish pressure at the engine throttle. The danger to the boiler of a reckless bravado or a careless ignorance in rapidly opening such a stop valve has already been reviewed. The sudden release of restrained pressure when the hot steam rushes at high velocity into the cool pipe produces a phenomenon of sudden boiling of the water at high temperature, and if this is concussive enough, the boiler may rupture under the stress and an explosion follow. But what happens in the line of pipe?

The pipe is first cool enough to condense the steam, lowering the pressure below atmosphere for a few seconds. If the drips are water-sealed in the drainage lines, or if the main drip pipe is full of water, the pressure of the atmosphere will start a flow of water backward or in the reverse or wrong direction through the branch drips, adding to the volume of cool water in the main line, and increasing the quantity which the drips must get rid of as fresh steam keeps coming along. In a few moments, however, the supply of steam raises the pressure enough to send condensation out at the rate determined by the size of the drips, and the pipe begins to warm. But the end furthest from the supply of the hot steam still remains the coolest; and if it be assumed that the drips are of niggardly diameter, or the steam traps

are sluggish in getting to work, there will be an accumulation of condensed water in concentric fittings, or in the sags of badly graded or poorly supported spans or where the building has settled. What will these pools of hot water do, as the steam rushes over their surfaces on its way to the far cool lengths of pipe?

There may four things happen, according to the conditions; and these may happen singly or together. If the water mass is small and of large surface compared to its mass, the rushing steam ruffles and ripples the surface, and if the water is hot enough, it vaporizes either to a gas or to a mist and is entrained forward harmlessly with the steam current. In other words, the pool is dried up by the steam, and the latter is moistened only, to a degree which matters little.

If the mass of water is larger and cool, and with a good contact surface, the second condition presents itself when the incoming steam is condensed by the water in the pool. The first consequence is the lowering of pressure locally and a higher velocity of steam in the pipe leading from the boiler to the point where the water lies; the second is the higher heating of the water there. Both of these consequences tend to establish the third set of conditions, where the mass of the water is too great to be subdivided or vaporized and where the velocity of the flow of steam is sufficient to lift the water bodily and send it forward as a mass of some concentration. Such mass yields reluctantly to any change of direction of its flow; and at an elbow or a tee or at a valve it fetches up with a sudden arrest, comparable to a hammer blow. The mass of water concerned and its living force determine the energy of the blow, which ranges all the way from the click click of an upholsterer's hammer in the small-pipe radiators of a heating system to the massive sledge stroke of a stone breaker's maul in a power-plant system.

Cast-iron fittings go down before such a sledge blow like so much glass. Lap-welded pipe splits along its sides. Flanges crack radially through the bolt holes; gaskets go out like hail; valve seats fail, stems bend. It is almost safe and true to say that nothing can stand up against these stresses, if the mass of water and the velocity of steam current were together sufficiently adjusted to each other.

Water hammer can also be expected in the early morning from a fourth set of conditions, where it becomes the concussive ebullition of the laboratory, and a bumping occurs. The mass of still or dead water had become gradually heated, and is now at a point when it is ready to form steam if the pressure is lowered, but cannot vaporize at the existing pressure. The condensation phenomenon of the second set of conditions lowers the pressure; whereupon the mass of highly heated water bursts into vapor at the lowered pressure, and either the reaction or the impact of the lifted water gives the blow to the pipe, with its stresses and its dangers, as in the case of the boiler shell formerly discussed.

These sets of conditions, of course, belong only to the early morning at the power plant because they are naturally there at that time. They may occur at any hour at which the temperature changes occur suddenly. They belong to the steam-power plant and not to the internal-combustion system. Their possibility points to the excellent safeguard which is presented in many designs of gate and stop valves in which a by-pass connection of small diameter and with its own valve controlling it, enables pressure to be let on from the high side to the lower only as fast as it can be established through such a small pipe.

Edison Company Gets New York Police Headquarters Building

It is announced that the New York Edison Company has secured a contract for lighting the new Police Headquarters' building. This building is equipped with a lighting and heating plant said to have cost in the neighborhood of $80,000.

Every engineer knows that where steam must be made for heating it costs very little more to make it at high pressure, run it through engines and heat with their exhaust. In a large building in New York 314,367 pounds of coal were used the last five days in February and 316,329 the first five days in November. In October the engines were not run. They were started up November first and developed in the five days under consideration 49,815 kilowatt-hours of electrical energy with a difference for the whole five days of less than a ton of coal whether the engines were running or not. This condition exists throughout the heating season. A few degrees of difference in the temperature has a greater effect upon the coal consumption than any demand for light. Condensing turbines of the largest size and greatest efficiency cannot produce current for so little money as a cheap slide-valve engine when the latter is charged only with the additional cost over running the plant for heating only.

In computing the total cost of power production the interest on the investment, depreciation and other standing charges must be taken into account. But in this instance the money is already spent, the plant is there; standing charges must be paid upon it whether it runs or not.

Evidently it was not engineering argument that shut down this isolated plant.

Engineering "Language"

Our especially esteemed English contemporary, *The Electrical Review*, referring to the slovenly writing in a certain technical book, recently said:

"It is not to be expected that in a book for use in the shops writing of a standard equal to that of Lord Morley should be found. We do think, however, that the literary engineer might be a little more literary without being less of an engineer." With this mildly expressed comment we heartily agree, though we are inclined to regret that our British fellow-scribe was too polite to say all that he really thought.

It is doubtful if the engineering student is hampered by any other one thing as much as he is by careless writing, or worse, on the part of technical writers. Here are a few samples, taken at random from recent publications:

"The engine works on the four-stroke cycle, but gives a working stroke in each cylinder, once every revolution."

"The coal burned in the boiler is the largest item of expense * * * *"

"The generating equipment comprises three 60-cycle three-phase turbines, of 2000 kilowatts each."

"Laminated fields are employed * * * * * * The fields are of strap copper wound on edge * * *"

Absolute accuracy of expression and purity of diction are neither expected nor necessary; but a writer who can't or won't do better than the foregoing examples should either put his manuscript through the hands of a competent editor or use it to kindle fires.

It has frequently been discovered that a jet of steam under the grates will prevent the formation of large clinkers and great credit is assumed by the discoverer. It is the intense heat of the fire that melts the incombustible in the fuel into a species of slag. If there is little heat there will be few clinkers. But to burn coal to make steam with which to reduce furnace temperatures seems to be somewhat short of the highest attainment in economical coal burning.

A representative of POWER called at the broker's office where stock in the Carbonic Engine and Power Company has been for sale and attempted to buy some stock, but was informed that the company had found they were mistaken with regard to Mr. Carroll and the value of his invention and had given up its exploitation.

Noncompression-Johnson seems to have some pretty heavy backers. Have you read what Professor Dwelshauvers-Dery and Chief Engineer Isherwood have to say about the subject?

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Rate of Radiation

If a pipe is heated to 212 degrees, does the rate at which it gives off heat depend on what is inside the pipe keeping the iron at that temperature?

H. D. E.

The rate of radiation depends on the difference of temperature between the pipe and the surrounding medium. With the pipe at a constant temperature the more nearly the surrounding medium approaches that temperature the less will be the radiation.

Temperature of Steam Next to Pipe

Will not a pipe containing superheated steam have a film of saturated steam next the pipe so that the iron will be at almost exactly the same temperature as though the pipe contained only saturated steam, and give off heat at the same rate?

A. R. G.

As the steam next to the pipe gives up its heat there may be a region of slightly lower temperature near the surface of the pipe, but how much lower this temperature is or whether it is lower at all, no one can say.

Currents from a Three-phase Generator

Does a three-phase generator deliver three currents, or are there two currents in two of the wires which combine in the third wire?

M. K. J.

Three distinct currents are "generated," and these combine with each other either in the generator armature winding or in the line wires, according to whether the armature is "star" or "delta" connected.

Pressure Required to Lift Valve

In an air compressor having spring-discharge valve, holding the valve to the seat with a pressure of 25 pounds and a pressure of 100 pounds in the receiver, what pressure will it take to lift the valve?

J. C. J.

Multiply the area of the opening under the valve in square inches by the pressure on the valve. To the product add the pressure of the spring, 25 pounds, and the weight of the valve if it is opened vertically upward and divide the sum by the area of the opening. This will give the pressure per square inch necessary to raise the valve.

Thickness of Boiler Shells

How can we determine the thickness of boiler plate to be used for any diameter of boiler for any pressure?

C. W. A.

The required thickness may be found by using the formula

$$T = \frac{PFR}{ES}$$

in which

T = Thickness of sheet.
P = Working pressure.
F = Factor of safety.
R = Radius of shell.
S = Tensile strength of sheet.
E = Strength of seam.

Tensile Strength

What is meant by the expression, tensile strength per square inch?

U. S. W.

It means the load or pull that is necessary to separate a bar or piece of the material named, having a cross-sectional area of one square inch.

Heating Surface of Corrugated Flue

How can the heating surface of a corrugated flue be figured?

A. M.

Multiply the average diameter of the flue in feet by its length in feet and the product by 4.93. For ordinary boiler horsepower calculations it is close enough to multiply the product of the diameter and length by 5.

Engine Running Under

Which way does an engine turn when it "runs under"?

F. B.

Standing at the cylinder and looking toward the flywheel, if the top of the wheel moves toward the observer the engine is said to run under; in the other direction it is running over.

Duplex Pump Cushion Valves

How can I set the cushion valves on a duplex pump and know that they are set right before I start the pump?

F. H. R.

You cannot, as the amount of cushion needed will depend upon the load on the pump, the speed at which it works and the steam pressure. Experiment only will tell when they are right, and if right for one set of conditions they may be entirely wrong for another.

Temperature of Steam Pipes

Will a pipe be hotter or cooler if it contains superheated steam than if it contained saturated steam at the same pressure?

M. A. B.

By definition, superheated steam is steam that has a temperature higher than that due to its pressure. Therefore, if the steam is superheated, the pipe containing it must have a temperature above that of a pipe containing saturated steam at the same pressure.

Changing Receiver Pressure

How can I change the receiver pressure on a compound Corliss engine from a lower to a higher pressure? For instance, if I am carrying 10 pounds receiver pressure and wish to change it to 15 pounds, do I change the valve gear on the high-pressure cylinder so as to give a later cutoff and on the low-pressure cylinder so as to cut off earlier in the stroke? I wish to do this without changing the sped of the engine.

M. B. J.

The receiver pressure is increased or diminished by lengthening or shortening the cutoff on the low-pressure cylinder only. To attempt it by altering the length of the knockoff rods on the high-pressure cylinder would throw the governor out of adjustment, possibly to a dangerous degree and would cause but little change in the receiver pressure.

Location of Fusible Plug

Will you please tell me where the fuse plug is located in a Babcock & Wilcox water-tube boiler?

E. G. W.

In the Babcock & Wilcox boiler the fusible plug is placed in the upper drum, not less than 6 inches above the bottom of the drum and over the first pass of the products of combustion and must project through the sheet not less than 1 inch.

New Power House Equipment

Ridgway Four Valve Engine

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

Appreciating the demand for a side-crank engine of four-valve construction embodying the maximum economy as well as reliability in service, the Ridgway Dynamo and Engine Company, Ridgway, Penn., has recently brought out a new line of engines the salient features of which are shown in the accompanying illustrations.

The frames of the new engine are of the box-section type with bored guides of large diameter. Main bearings are fitted with quarter boxes adjusted horizontally with wedges and vertically by varying the position of the bearing cap, the parts subject to wear being removable without

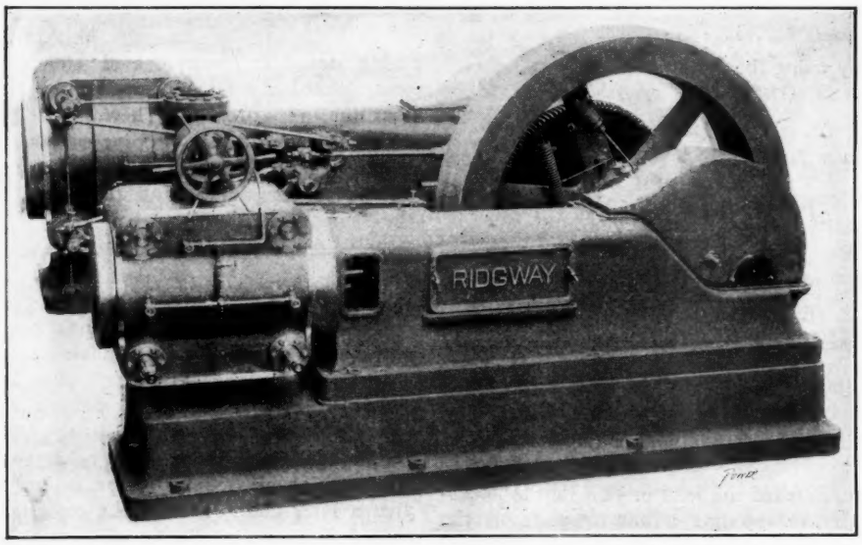


FIG. 1. RIDGWAY SIDE-CRANK CROSS-COMPOUND FOUR-VALVE ENGINE

dismantling the engine. Another feature which differs from usual construction is the crosshead. This has a body of cast steel and heavy shoes of cast iron, which are easily adjusted. Four hollow bolts pass through the crosshead body and inside of these bolts are placed the cap bolts which hold the shoe firmly. By means of a locknut on these bolts the bottom shoe may be adjusted at any desired point and fixed firmly in position. Two ribs extending from the crosshead fit snugly into the shoes and prevent any end play of the latter. If desired, the construction is such that shims may be placed under the crosshead in addition to the adjustment provided by the cap bolts.

A handy feature of the engine is the arrangement for checking alinement. On the inside of the crank case are three reference surfaces or spot marks, finished when the main bearing is machined. The crank disk is also finished after the crank has been forced on the shaft, so that it is known to be absolutely square with the shaft, being finished on the same centers. In testing the alinement it is done by calipering the distance between any one of the spots and the crank disk and turning through 180 degrees and checking the distance. After this is done at all three spot marks and the distances are found to be equal, the engine is known to be in proper alinement.

Splash lubrication is ordinarily employed, the crank case being inclosed and suitable oil ducts arranged for this purpose. At the crank end of the crosshead guide, which latter is isolated from the cylinder by a sectional diaphragm, there is a well cast in the frame into which all oil and water must flow before reaching the crank case. This furnishes a settling chamber where impurities are precipitated and the water is drawn out through a goose-neck drain. This well being removed from the heat of the cylinder gives the oil an opportunity of cooling before being used again for lubrication. An automatic system of gravity feed and circulating pump is supplied when ordered.

The striking feature of the engine and the one embodying the most novel departure from ordinary designs is found in the valve gear. It will be noted in Fig. 3 that each valve has a valve rod connecting it with a gear box, so called, fastened to the main body of the frame. The exhaust valves are actuated by a fixed eccentric through the medium of a double bell crank upon which is attached the connections for the exhaust-valve rods. This construction gives the same action as if a wristplate were used, but has the effect of concentrating the valve gear at one point and accomplishes its purpose with the minimum of parts. The steam valves connect through a system of toggle joints with the governor eccentric, in such a manner that the action when opening and closing is extremely rapid, and the valve is at rest at other times. Fig. 4 shows the gear box in detail, from which the construction will be readily understood. In this gear all bearings are lined with bronze and are adjustable. The parts of the gear are accessible through the top of the gear box for adjustment and inspection, and by removing the top half of the box the entire gear is laid bare for repairs when necessary. The toggle joints consisting of outside and inside arms and shafts are all in one piece and the connections are made with hardened and ground-steel pins and links with

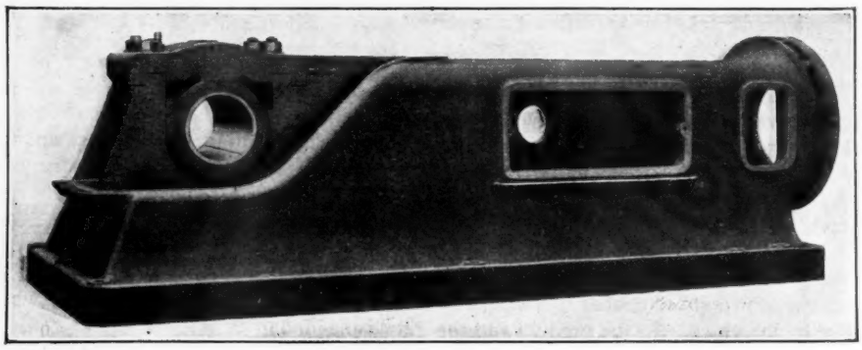


FIG. 2. ENGINE FRAME OF BOX SECTION TYPE

wedge adjustment for taking up wear. The entire gear runs in a bath of oil and is noiseless in operation. Fig. 4 shows the action of the gear at two different positions, one at mid-stroke and the other at one of its extreme points of travel. The peculiar construction insures that the opening and closing of the valves will occur at the time of maximum velocity and that the opposite valve will remain at rest during the major portion of the unbalanced period. A surprisingly small movement of the steam valves is necessary to get full port opening. The valves themselves are ground to fit in a removable bushing as shown in Fig. 5, and are reversible. They are also symmetrical in shape, which minimizes all tendency to warping and leakage due to the temperature of the steam. The construction is such that the valves are double-ported with a single port in the cylinder, and have the minimum of lap, thus requiring little power in moving when under steam. Fig. 5 is a sectional view of the cylinder showing the double-ported action of both steam and exhaust valves and also the construction of the piston. As the steam valves fit perfectly their bushings, some other means of relieving the cylinder of condensation must be provided than the ordinary one of allowing the steam valves to raise against the steam pressure. This is accomplished by providing a cored passage at the end of each exhaust valve, connecting with the exhaust-valve bonnet, into which are screwed the relief valves, so that before the valve is closed to the exhaust the passage is open and remains open to the relief valves as long as the exhaust valve itself is shut. By this method the cylinder is drained at its lowest point in the most logical manner. The valves are all made of minimum diameter to decrease the power required to move them under pressure, it being one of the objects of the design to reduce to the minimum the power required to operate the valve gear, thus reducing the amount of wear. All valve-gear connections are adjusted with wedges or split bushings and are lubricated with grease cups, the cups, wherever possible, being placed in the center of motion so that they may be easily operated and refilled while the engine is in service. An interesting feature of the cylinder construction is found in the fact that there are no bridges cast over the steam or exhaust ports as in ordinary practice. This removes all uncertainty in regard to shrinkage strains in the casting at this point. In place of the narrow bridges of

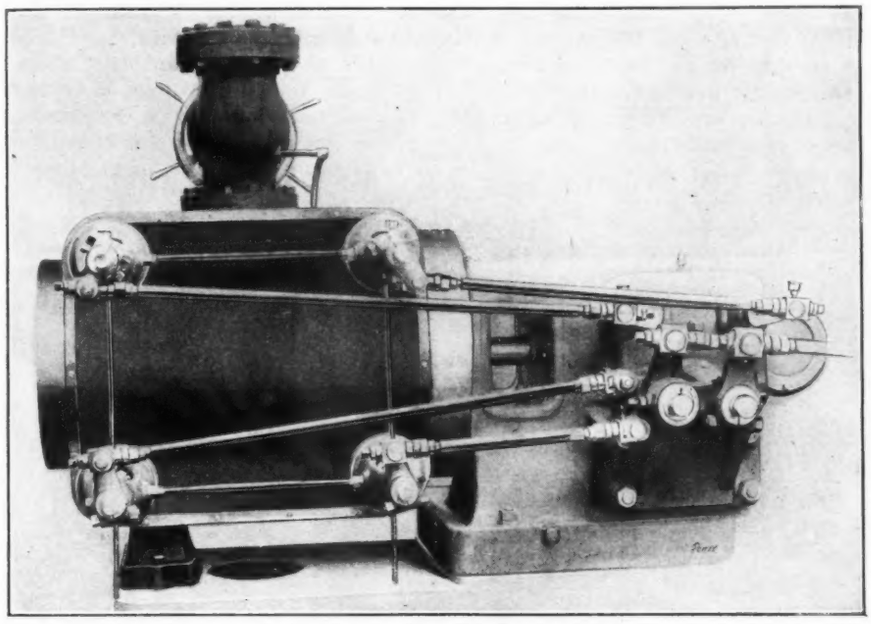


FIG. 3. RIDGWAY VALVE GEAR AT CLOSE RANGE

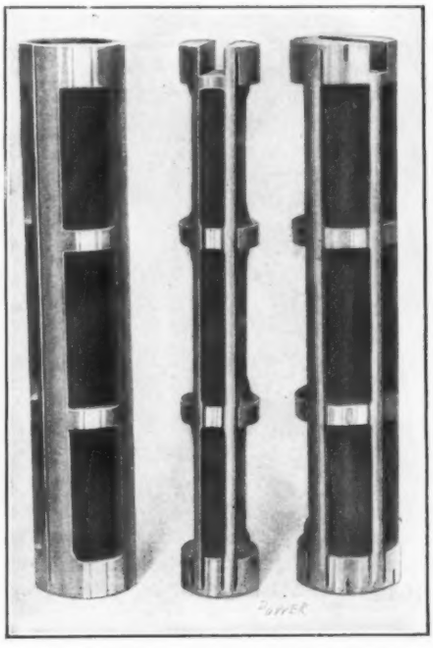


FIG. 6. STEAM AND EXHAUST VALVES

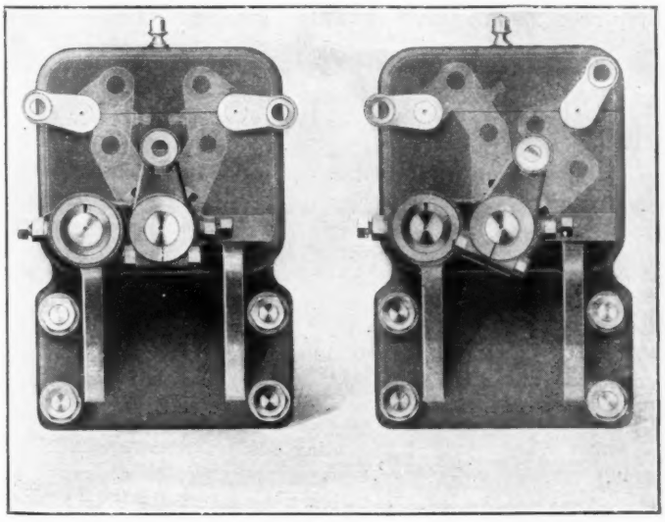


FIG. 4. DETAILS OF STEAM VALVE GEAR

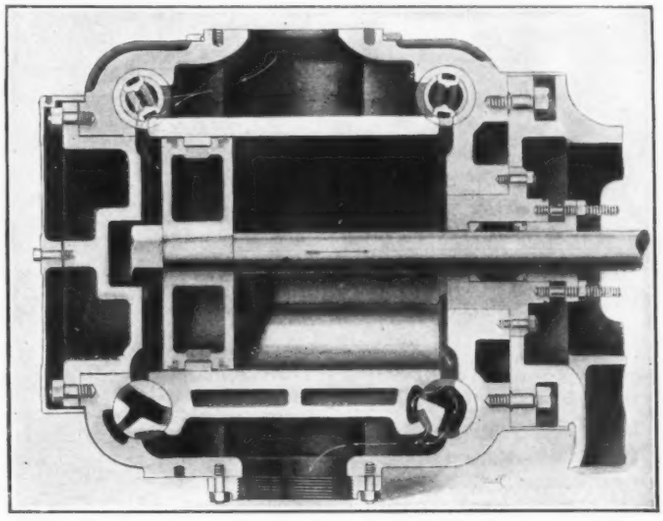


FIG. 5. CROSS-SECTION OF RIDGWAY FOUR-VALVE CYLINDER

cast iron, strong screw bolts conveniently spaced are inserted in the cylinder to take up the tension due to pressure on the cylinder head.

The governor is of the Ridgway centrifugal, inertia type, with the governor arm

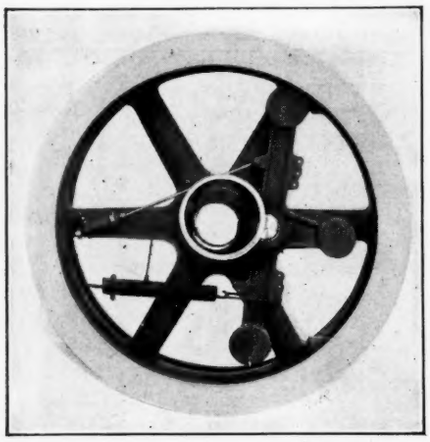


FIG. 7. RIDGWAY GOVERNOR WITH DASHPOT AND BALANCE WEIGHT ON GOVERNOR ARM

supported on a roller bearing working in a hardened and ground steel bushing. An oil dashpot with loosely fitting piston, and

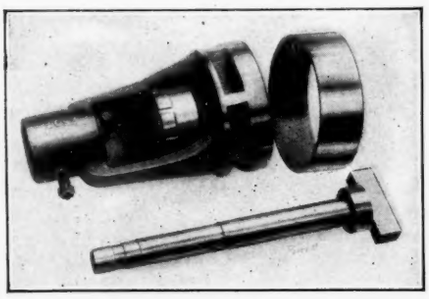


FIG. 8. DETAILS OF STEAM BONNET

bypass with needle valve, regulates the sensitiveness of the governor, another feature of which is the additional weight placed opposite the eccentric. This not only balances the latter but has a gyroscopic action which holds the eccentric in its proper plane and steadies the action of the valve gear. Fig. 7 illustrates the simplicity of the assembled governor.

Details of the engine have been thought out with great care. The throttle valve is provided with a bleeder which is connected to the steam chest and also with the indicator piping so that the engine can be warmed up and steam may be turned into either end of the cylinder at will. Other features are fully as complete. The valve bonnets have the merit of unusual accessibility. Fig. 8 shows the construction of one of these bonnets, the opening required for packing being unusually ample and the outboard bearing providing a substantial support for the valve rod. The pistons are cast hollow, heavily ribbed, and are provided with a ring of antifriction metal, on each side of which is a cast-iron snap ring of special design. The main outboard bearing consists of a babbitted bushing resting on a ball-and-socket joint, which is self-aligning. These engines are given a rigid shop test under load before shipping and have shown unusual economy as a result of their careful design.

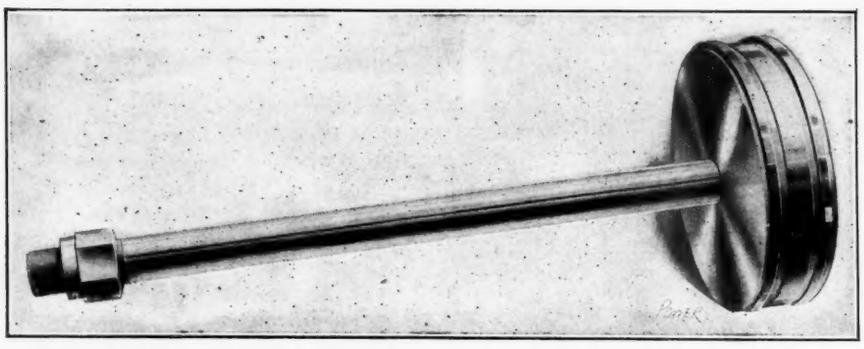


FIG. 9. PISTON AND ROD, SHOWING ANTIFRICTION METAL AND SNAP RINGS

Circulating Device for Scotch Marine Boiler

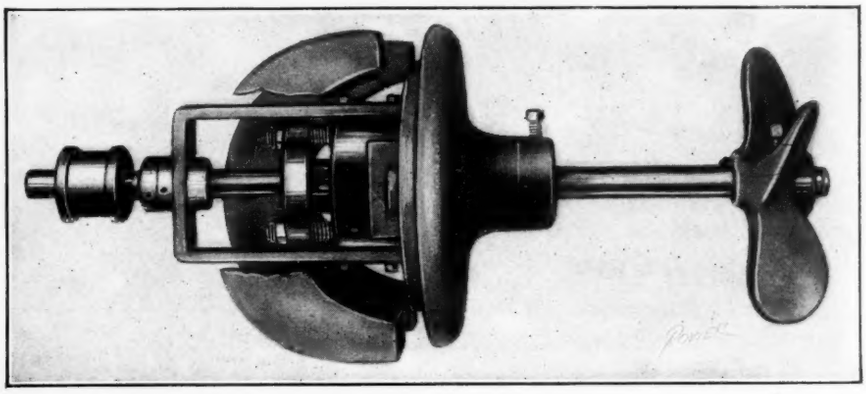
Owing to the construction of Scotch marine boilers the circulation of the water is not as free as in water-tube and return-tubular boilers. Consequently, if care is not taken in getting up steam, when the water is cold, there is danger of causing leaky joints.

Many devices have been developed to increase the water circulation in this type of boiler and maintain an even temperature throughout the whole mass, but they have failed, due to imperfection of one kind or another.

The Wheeler circulating device, illustrated and described herewith, produces the desired results independently of any energy in the boiler itself, and is positive in action. The illustrations show the simplicity of the device.

It is attached to the manhole of a boiler, as shown, and its application does not in any way necessitate alterations to the boiler, or even to an extent of an additional bolt or screw, as the circulator is carried by the manhole cover, of which it forms a part, and is easily removed and replaced with little trouble.

The circulator consists of a shaft carrying a small propeller on one end and a sprocket or belt pulley on the opposite end. Where the shaft passes through the manhole cover, an ordinary stuffing box is employed, and the whole device is held in place with the usual bolts that secure the manhole plate to the boiler.



CIRCULATING DEVICE

Lubrication of the shaft is maintained by the use of a grooved bushing carrying the lubricant. It requires about 1/16 horsepower to drive the circulator. This device has been patented by Edwin J. Wheeler, Y. W. C. A. building, Schermerhorn street, Brooklyn, N. Y.

According to the *Electrician* the Berlin electricity works have recently published some figures showing the saving in the cost of oil due to the displacement of reciprocating engines by steam turbines. In the fiscal year 1905-1906, when the first turbines were erected, there were required 554,514 pounds of cylinder oil, and 206,373 pounds of engine oil. The output of the station for the year in question was 166,865,122 kilowatt-hours. In the fiscal year 1909-1910, the output of the station was about 210,000,000 kilowatt-hours, but owing to the fact that the station is now operated entirely by steam turbines, the consumption of cylinder oil was only 103,400 pounds, and of engine oil also 103,400 pounds.

Ohio State N. A. S. E. Convention

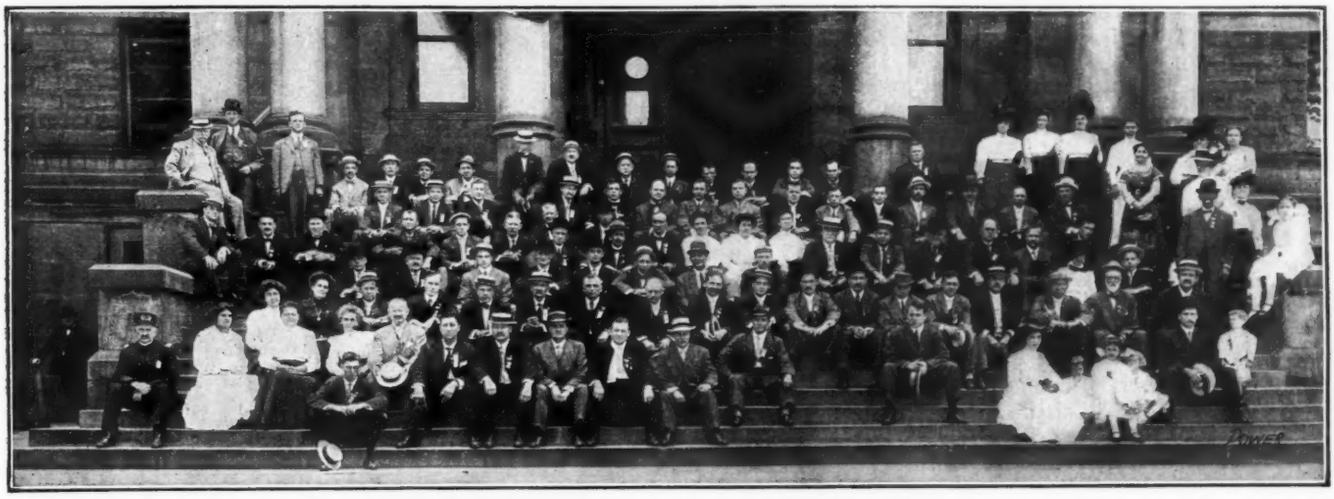
Hamilton entertained the delegates to the Ohio State convention of the National Association of Stationary Engineers, June 16, 17 and 18. Introductory exercises were held at the K. of P. hall, where, after invocation by Rev. S. B. Hiley, Mayor Abe Rothwell welcomed the delegates to the city. F. H. Yeager, of Cincinnati, responded in behalf of the association. Another address by John Fahrenbach, of Cincinnati, which contained much valuable advice to the delegates, was entitled "Legislation." Mr. Fahrenbach spoke from long experience in these matters, having been identified with legislative affairs of the National Association of Stationary Engineers in Ohio from the beginning. It is desired by the association to pass a boiler-inspection law, and when this is done, Ohio, which now has a successful license law, will be thoroughly equipped in these matters.

Officers for the ensuing year were elected as follows: Harry Eichorn, of Columbus No. 38, president; J. J. Coughlan, of Hamilton No. 4, vice-president; Joseph J. Ahlers, of Cincinnati No. 2, secretary; J. E. Radigan, of Cleveland No. 5, treasurer; Casper Geise, of Delphos No. 51, conductor; William Long, of Toledo No. 3, doorkeeper, and E. F. Synnett, of Dayton No. 37, State deputy, the latter being reëlected.

Entertainment for the visitors was lavishly provided, a notable feature being an automobile ride around the city, ending up at the plant of the Hooven-Owens-Rentschler Company, where they were given the freedom of the shops and had the opportunity of inspecting some very large engines under course of construction. Dancing and theater parties were also features of the social program, which wound up with a picnic for visitors and delegates at Ohlinger's grove, on Saturday afternoon.

Supplymen were liberally represented, the following firms having booths in exhibit hall:

Albany Lubricating Company, V. D. Anderson Company, American Steam Gauge and Valve Manufacturing Company, Anchor Packing Company, Armstrong Manufacturing Company, Arrow Boiler Compound Company, Brownell Company, Crandall Packing Company, Dearborn Drug and Chemical Works, Fairbanks Company, Garlock Packing Company, Greene, Tweed & Co., Hawkeye Compound Company, Hooven-Owens-Rentschler Company, Indian Refining Oil Company, International Acheson Graphite Company, Jenkins Brothers, H. W. Johns-Manville Company, Keystone Lubricating Company, Lagonda Manufacturing Company, Limbert Successful Flue Blower



OHIO STATE DELEGATES AND VISITORS AT HAMILTON

PHOTOGRAPH OF THE DELEGATES TO THE PENNSYLVANIA N. A. S. E. STATE CONVENTION, WHICH ARRIVED TOO LATE TO APPEAR WITH THE REPORT

Company, Lunkenheimer Company, George W. Lord Company, Charles H. Moore Oil Company, McLeod-Henry Company, Murdock Manufacturing and Supply Company, F. W. Niebling Company, Platt Iron Works, Peerless Rubber Manufacturing Company, William Powell Company, POWER AND THE ENGINEER, *Practical Engineer*, John A. Roebling Sons Company, *Southern Engineer*, Under-Feed Stoker Company of America, Victor Rubber Company, John L. Walker Company, D. T. Williams Valve Company and G. A. Weigel Company.

NEW PUBLICATIONS

TWENTIETH CENTURY HANDBOOK FOR STEAM ENGINEERS AND ELECTRICIANS, WITH QUESTIONS AND ANSWERS. By Calvin F. Swingle. Published by Frederick J. Drake & Co., Chicago, Ill. 1481 pages, 6¾x4½; flexible leather, flap cover. Price, $3.

This is a revised and enlarged edition of the author's effort to produce a handbook that would meet the wants of the working engineer and electrician. There have been additions made to the text in nearly every chapter and several new subjects have been introduced, including air compressors, elevators, hydraulic belt and electric, gas engines, steam turbines and the design, construction and erection of steam machinery.

Each chapter is followed by a list of pertinent questions accompanied with concise answers. There are nearly 700 illustrations and the work is fully indexed.

SELF-TAUGHT MECHANICAL DRAWING AND ELEMENTARY MACHINE DESIGN. By F. L. Sylvester and Erick Oberg. Norman W. Henley Publishing Company, New York. 333 pages; 5x7½ inches; cloth. Price, $2.

A treatise intended primarily to aid the young draftsman in obtaining a sound knowledge of the fundamentals of mechanical drawing and machine design. The work is arranged and written in such a manner as to make self-study possible.

The first chapter is devoted to the subject of instruments and drawing materials and contains a number of those useful hints, so necessary at the start, toward the making of a successful draftsman. Constructive problems in geometry and projection are next taken up and the principles of mechanics and trigonometry are stated, with enough problems in application to afford an intelligent understanding. No attempt has been made to go into the finer points of machine design but chapters on the strength of material, gearing, shafting, pulleys, flywheels and cams give a working knowledge of the subject.

One point of criticism might be made; that, the rather poor quality of paper used makes the reading difficult in some places.

THE SLIDE RULE. By J. J. Clark, Technical Supply Company, Scranton, Penn. 62 pages, 4¾x6¾ inches; Cloth. Price, 50 cents net.

Despite the fact that there are numerous books on the slide rule, the author thinks that none existed before his effort was printed, which was couched in language sufficiently plain that it could be easily understood by one of ordinary mental equipment.

Beginning in section 10, with "According to the theory of exponents, the product of a number having an exponent, and the same number having a different (or an equal) exponent is equal to this same number affected by an exponent equal to the sum of the exponents," the book is not any more free from involved sentences and obscure references than other books on the same subject.

The first nine sections show in a clear manner how addition or subtraction is performed by adjusting two identical linear scales so that the results may be read off without going through the mental process of the operation. Had the author followed these sections with a description of the manner in which a similar manipulation of two logarithmic scales would give the product or quotient of two numbers and had he left an explanation of the principle involved for later elucidation, greater clearness would have been secured and the value of the book to the beginner would have been greatly increased.

The author's suggestions regarding the selection and care of a slide rule, given in sections 67 and 68, are valuable.

It is probable that this book will be of greater worth to those who have had a preparation in higher mathematics than to those who have a knowledge of only the common branches of the subject.

SOCIETY NOTES

The fifteenth annual convention of the Massachusetts State Association, National Association of Stationary Engineers, will convene at Runels' hall, Merrimack square, Lowell, Mass., on July 7, 8 and 9. The committee from Lowell No. 17 which has charge of the arrangements, has worked hard for the success of the convention and from all indications the largest number of delegates, guests and exhibitors that have ever attended any State convention will be present. Space in the large exhibition hall has practically all been taken. The halls for the convention and the exhibition are located in the center of the city where all lines of electric cars entering the city center, thus making it very convenient for visitors from nearby cities who come by trolley. The Richardson hotel, directly opposite the depot, has been selected as State headquarters. All inward-bound cars passing the door, go direct to the halls. An interesting program has been prepared and the "bunch" will be present to see that everyone has a good time.

Annual Report of Westinghouse Company

On June 21 the annual meeting of the stockholders of the Westinghouse Machine Company was held in East Pittsburg. The following extract from the report of Haskins & Sells, certified public accountants, may be of interest:

Average annual net income available for interest and dividends, or for capital accounts for the eight years ended March 31, 1910.....	$720,543.78
Average annual net income available for interest and dividends, or for capital accounts, for the five years ended March 31, 1910.....	736,719.05
Average annual net income available for interest and dividends, or for capital accounts, for the period from April 1, 1903, to March 31, 1910, exclusive of the years ended March 31, 1908 and 1909....	841,149.86

The two fiscal years eliminated cover a period of general business depression and of the receivership and reorganization of the company.

New income available for interest and dividends, or for capital accounts, for the year ended March 31, 1910.....	875,845.33
Net income available for interest and dividends, or for capital accounts, for the quarter ended March 31, 1910, $330,-286.38, or at the rate per annum of.....	$1,321,145.52

It is of interest to note that the orders received for shop product during the fiscal year just closed, ending March 31, 1910, aggregated $5,123,612.52, an increase of $2,322,536.88, or 83 per cent., as compared with $2,801,075.64 during the previous fiscal year; that the billing in shop product for the fiscal year amounted to $4,065,618.74, an increase of $1,309,-912.94, or 48 per cent., as compared with $2,755,705.80 during the previous year; and that the net addition to surplus after deducting depreciation and interest charges (excluding the amount written off for an investment in a subsidiary company manufacturing storage batteries, which was liquidated during the year) is $429,566.61, as compared with a loss of $228,123.54 during the previous year, a betterment over the previous year of $657,690.15.

Compressed air for signaling from the bottom of shafts to the hoisting-engine room at the surface is used at the Moodna pressure tunnel of the Catskill aqueduct. An air pipe extends up the shaft and into a cylinder alongside of the hoist runner; in this cylinder is a metal piston or plunger which strikes against a gong when pressure is applied.

NEW INVENTIONS

PRIME MOVERS

ELASTIC FLUID TURBINE. Louis C. Loewenstein, Lynn, Mass., and Leonard H. Dyer, Greenwich, Conn., assignors to General Electric Company, a Corporation of New York. 960,357.

INTERNAL COMBUSTION ENGINE. Charles A. Bennett, Dover, N. J. 960,254.

ELASTIC FLUID TURBINE. Oram A. Boyer, Harrisburg, Penn. 960,260.

GAS-ENGINE CYLINDER. Fred Elmer Norton, Youngstown, Ohio. 960,385.

WIND MOTOR. Abel W. Pickering, Joplin, Mo., assignor of one-sixth to Alva A. Russell, one-sixth to Thomas A. Moon, and one-sixth to W. Roscoe Haughawout, Joplin, Mo. 960,394.

STEAM ENGINE. Herbert L. Thompson, Elgin, Ill. 960,438.

GAS ENGINE. Archibald Burnett, Phœnix, British Columbia, Canada. 960,498.

ROTARY ENGINE. Bert Dorris, Bloomfield, Ind. 960,516.

INTERNAL COMBUSTION ENGINE. John E. Gilson, Port Washington, Wis., assignor to Gilson Manufacturing Company, Port Washington, Wis. 960,536.

TURBINE. William F. Wegner, New York, N. Y., assignor to Stephen T. Williams, New York, N. Y. 960,747.

ENGINE. William E. Blair, Bay City, Mich. 960,797.

HYDRAULIC MOTOR. George B. French, Fremont, Neb. 960,876.

GAS ENGINE. David Walter Lyon, Alameda, Cal. 960,978.

ROTARY ENGINE. Newell H. Motsinger, Greensburg, Penn. 960,990.

ROTARY ENGINE. Newell H. Motsinger, Greensburg, Penn. 960,991.

ROTARY ENGINE. Newell H. Motsinger, Greensburg, Penn. 960,992.

ROTARY ENGINE. Newell H. Motsinger, Greensburg, Penn. 960,993.

ROTARY ENGINE. Newell H. Motsinger, Greensburg, Penn. 960,994.

ROTARY MOTOR. George R. Riggs, Allegheny, Penn. 961,017.

ROTARY ENGINE. Anatol J. Savoie, Glencoe, La. 961,026.

ELASTIC FLUID TURBINE. Giuseppe Belluzzo, Milan, Italy. 961,067.

GAS ENGINE. Carl G. Sprado, Milwaukee, Wis., assignor to Allis-Chalmers Company, Milwaukee, Wis., a Corporation of New Jersey. 961,079.

LOW-PRESSURE STEAM TURBINE. Johann F. M. Patitz, Milwaukee, Wis., assignor to Allis-Chalmers Company, Milwaukee, Wis., a Corporation of New Jersey.

BOILERS, FURNACES AND GAS PRODUCERS

HYDROCARBON GAS BURNER. Leo F. Millard, Whitewater, Wis. 960,336.

FURNACE. Jacob Weintz, Cleveland, Ohio, assignor to the Strong, Carlisle & Hammond Company, Cleveland, Ohio, a Corporation of Ohio. 960,463.

OIL BURNER. Robert A. Bright, Jacksonville, Fla. 960,491.

CRUDE-OIL BURNER. Julius J. A. Latil, Baton Rouge, La. 960,563.

HYDROCARBON BURNER. Louis A. Sherman, Detroit, Mich. 960,722.

CRUDE-OIL BURNER. Charles Shaeffer, Paris, Tex. 961,030.

STEAM BOILER. James Buyhers, Casey, Ill. 961,082.

POWER PLANT AUXILIARIES AND APPLIANCES

PUMP GOVERNOR. Telesphore J. Beaudette, Los Angeles, Cal. 960,249.

EMERGENCY GOVERNING MECHANISM FOR TURBINES. Frederic R. C. Boyd, Lynn, Mass., assignor to General Electric Company, a Corporation of New York. 960,259.

RATE-INDICATING DEVICE FOR FLUIDS. Frederick N. Connet, Providence, R. I. 960,275.

VALVE. John A. Deasy, Detroit, Mich. 960,280.

EMERGENCY GOVERNING MECHANISM FOR TURBINES. Edgar F. Dutton, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 960,289.

PRESSURE-RELIEF VALVE. Jackson W. Foster, Jacksonville, Fla., assignor of one-half to Albert Endel and one-fourth to Walter C. Warrington, Jacksonville, Fla. 960,302.

COMBINED PIPE COUPLING AND VALVE. John N. Goodall, Portsmouth, N. H., and Frank S. Head, Stoneham, Mass. 960,309.

STOP AND WASTE COCK. Thomas B. Hensey, Adrian, Mich. 960,323.

SPEED INDICATOR. Alexander May Hudson, New York, N. Y. 960,329.

ROTARY PUMP. George W. Keller and Edward C. Goetz, Portsmouth, Ohio. 960,329.

LUBRICATING DEVICE. Thomas G. Kincaid, Connellsville, Penn. 960,341.

BELT TIGHTENER. Arthur F. Kwis, Norwood, Ohio, assignor to Allis-Chalmers Company, a Corporation of New Jersey, and the Bullock Electric Manufacturing Company, a Corporation of Ohio. 960,347.

GOVERNOR. Nathaniel Lombard, Winthrop, Mass. 960,358.

FEED-WATER HEATING APPLIANCE. Carl J. Mellin, Schenectady, N. Y., assignor to American Locomotive Company, New York, N. Y., a Corporation of New York. 960,364.

SEPARATOR. Josef Muchka, Vienna, Austria-Hungary. 960,374.

EMERGENCY GOVERNOR. Frederick Samuelson, Rugby, England, assignor to General Electric Company, a Corporation of New York. 960,411.

CONDENSER. William Schwanhausser, New York, N. Y., assignor to Henry R. Worthington, New York, N. Y., a Corporation of New Jersey. 960,417.

STARTER FOR HYDROCARBON ENGINES. Odilon Brisbois, Chicago, Ill., assignor to Automatic Starter Company, Chicago, Ill., a Corporation of Illinois. 960,493.

BOILER-TUBE CLEANER. Edward J. Buckmaster, Laurel Hill, N. Y. 960,496.

PUMP. Frank Negley, Alameda, Cal. 960,575.

VALVE. Marion Warren, Rochester, N. Y. 960,605.

ELECTRICAL INVENTIONS AND APPLICATIONS

AERIAL ELECTRIC CABLE. Carl Emil Egner, Stockholm, and Reinhold Frithiof Fredriksson, Gothenburg, Sweden. 960,291.

ELECTRIC SWITCH. Edward M. Hewlett, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 960,324.

ELECTROPNEUMATIC AIR-BRAKE SYSTEM. George Macloskie, Schenectady, N. Y., assignor to General Electric Company, New York, N. Y. 960,361.

INSULATION JOINT. Andrew McLean, Detroit, Mich. 960,377.

DYNAMO ELECTRIC MACHINE. Jakob E. Noeggerath, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 960,383.

ELECTRIC HEATER. James Charles Boyce, Toronto, Ontario, Canada. 960,409.

DYNAMO ELECTRIC MACHINE. Louis E. Underwood, Lynn, Mass., assignor to General Electric Company, a Corporation of New York. 960,449.

POWER OPERATED SWITCH OR CIRCUIT BREAKER. Herbert W. Cheney, Norwood, Ohio, assignor to the Bullock Electric Manufacturing Company, a Corporation of Ohio. 960,504.

MULTIPLE-VOLTAGE SYSTEM OF MOTOR CONTROL. Herbert W. Cheney, Milwaukee, Wis., assignor to Allis-Chalmers Company, a Corporation of New Jersey. 960,505

ELECTRIC ACCUMULATOR. Leon Marseille, Paris, and Paul Gouin, Levallois-Perret, France. 960,567.

ELECTRIC SWITCH FOR INCANDESCENT LAMP CIRCUITS. William Blacknell Crossland, De Soto, Mo. 960,626.

ELECTRIC VALVE CONTROLLER. Alonzo T. Wilson, Des Moines, Iowa, assignor of one-half to William H. Nicholas, Des Moines, Iowa. 960,757.

ELECTRIC FURNACE. Thaddeus F. Baily, Alliance, Ohio. 960,773.

ELECTRIC FURNACE. John W. Evans, Belleville, Ontario, Canada. 960,862.

ALTERNATING-CURRENT MOTOR. Valere Alfred Flynn, London, England. 960,881.

FUSE FOR ELECTRICAL CIRCUITS. Samuel M. Kintner, Pittsburg, Penn., and Girard B. Rosenblatt, New York, N. Y., assignors to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 959,552.

MAGNETIC CLUTCH. Frederick Ripon Martin and Oswald Montagu Shepherd, London, England. 959,569.

SWITCH FOR INCANDESCENT LAMPS. James A. Mebane, South Boston, Va. 959,572.

ELECTRIC VALVE. Frank N. Roehrich, Jersey City, N. J., assignor to George P. Carroll, Bridgeport, Conn. 959,609.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., W. W. Freeman, Brooklyn, N. Y.; sec., T. C. Martin, 33 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railway, Cleveland, O.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City. Next semi-annual meeting, St. Louis, Mo. June 30 and July 1, 1910.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Rochester, N. Y., September, 1910.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August 2-5, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, 606 Main St., Peoria, Ill. Next convention, Denver, Colo., September, 1910.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power and the Engineer.

A New England manufacturer recently said to an advertising solicitor for POWER AND THE ENGINEER, "I believe that my new machine is one of the best on earth for its purpose. It is the result of years of thought and work. But it has just one defect,—a slight one comparatively, but enough to make it a poor advertising proposition.

"I could sell many of them through your paper, but they wouldn't stay sold. That little defect would develop shortly and my money and effort would have been wasted.

"I couldn't get a single repeat order nor an order through the recommendation of a user; and you know as well as I do that my advertising would prove a failure unless my goods made good.

"When I have remedied that defect, you can gamble I'll be with you.

"But I can't afford to put our trademark on this machine and advertise it, because it has not yet reached the *standard* which our trademark represents."

There's an illuminating point in those remarks for every buyer of power-plant machinery and equipment.

When a manufacturer adopts and advertises a trademark he guards it jealously. For him it possesses a living, breathing personality—an individuality. It is *himself*—his aims, his objects, his ideals.

He knows that, properly advertised and lived up to, that trade mark becomes the most valuable asset in his business.

He knows that, once well known and established, the "good-will" represented by that trademark will bring a greater price than his factory, his equipment, his office furniture, the office cat and the office boy combined.

If you doubt that, try to buy the right to do business as jewellers and silversmiths under the name of Tiffany & Co.

Their enormous stock of precious stones, their objects of silver and gold are not worth one part of the value of the simple firm name.

When a manufacturer trademarks a machine he sets upon it the seal of his belief in it.

Then he spends thousands to advertise it with the belief that the *repeat orders* will pay him for his advertising investment.

He knows the machine from A to Izzard—how it will work under all manner of conditions.

This development work is costly to him, but he knows it is necessary.

So he tries it out, works over it, experiments in all directions until he knows it is right.

Then he advertises.

Under these circumstances is it to be wondered at that goods continuously advertised are *reliable?*

Or can there be any doubt that it *pays* to read advertisements and buy advertised goods?

* * * *

A trademark is not necessarily a picture nor a "slogan," nor does it necessarily, in the sense we refer to it, have to bear the word "Trademark."

It may be just the name of the firm.

Honest firms are not putting their name onto dishonest goods.

And dishonest firms are not doing much advertising. They can't.

Suppose, for instance, that a concern advertising in POWER were, through some oversight on the part of their advertising writer, to make a technical misstatement in their advertisement.

How long would it take the well informed, lynx-eyed readers of POWER to discover the error and flood the editorial department with letters?

We know because it has happened.

And advertisers know it too. None of them is looking for such unfavorable publicity.

The "white light that beats upon a throne" isn't a circumstance to the flooding brilliancy surrounding advertised goods.

It is your measure of protection when you go into the market to buy.